COPE'S RULE AND MACROEVOLUTION OF CENOZOIC MACROPERFORATE PLANKTONIC FORAMINIFERA

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A thesis submitted for the degree
Doctor of Philosophy at Cardiff University, 2011.

For my parents and Frazer

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Abstract

A comprehensive phylogeny of macroperforate planktonic foraminifer species of the Cenozoic Era (~65 million years ago to present) is presented. The phylogeny is developed from a large body of palaeontological work that details the evolutionary relationships and stratigraphic (time) distributions of species-level taxa identified from morphology ('morphospecies'). Morphospecies are assigned to morphogroups and ecogroups depending on test morphology and inferred habitat, respectively. Because gradual evolution is well documented in this clade, instances of morphospecies intergrading over time have been identified, allowing the elimination 'pseudospeciation' and 'pseudoextinction' from the record and thereby permit the construction of a more natural phylogeny based on inferred biological lineages. Each cladogenetic event is determined as either budding or bifurcating depending on the pattern of morphological change at the time of branching. This lineage phylogeny provides palaeontologically calibrated ages for each divergence that are entirely independent of molecular data. The tree provides a model system for macroevolutionary studies in the fossil record addressing questions of speciation, extinction, and rates and patterns of evolution. Specifically for this thesis the phylogenies provide a statistically robust framework for testing Cope's rule (the evolutionary trend towards larger body size along a lineage). Eleven case studies were selected at random from all possible Neogene lineages and the mean areas of ancestor and descendant populations were compared. Over 6000 measurements were taken from 30 lineages and the resulting data show that Neogene macroperforate planktonic foraminifera do not support Cope's rule with only 48% of the ancestor-descendant population comparisons demonstrating an increase in mean area. The size analysis illustrates that the most robust method for testing Cope's rule is to compare ancestor-descendant populations from the beginning and end of evolutionary lineages as these are the least affected by temporal sampling biases.

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1. Introduction

1.1 Cope's Rule

Cope's rule states that organism body size tends to become larger along an evolutionary lineage. The eponymous rule was inferred by the American anatomist and palaeontologist Edward Drinker Cope in his 1887 publication "*The Origin of the Fittest, Essays on Evolution*". Cope was a prolific publisher of academic papers, totalling over 1300 publications in his lifetime (Osborne, 1929). This number can partly be attributed to a fierce 20 year academic feud between Cope and Othniel Charles Marsh called the 'Bone Wars'. During this time both men were trying to out-compete the other naming new Paleocene vertebrate species from North America. It was during this intense-period of fossil collecting that Cope noticed a tendency to larger body size of the Paleocene mammalian faunas of North America (Alroy, 1998). Cope ascribed this phenomenon to new groups commonly being founded at smaller sizes and an evolutionary advantageous directionality towards larger size (Cope, 1887).

Cope's rule has had an extensive and long-lasting history of research with studies supporting an actively driven trend of size increase (Alroy, 1998; Kingsolver & Pfennig, 2004; Laurin, 2004; Hone *et al*., 2005; Clauset & Erwin, 2008; Novack-Gottshall & Lanier 2008), studies that show little support (McNamara, 1990; Jablonski, 1997; Moen, 2006; Monroe & Bokma, 2010), and studies that have ascribed the rise in mean size as a passively occurring trend due to the foundation of many clades at initially small sizes (Stanley, 1973; Gingerich, 1980; McKinney, 1986; Gould, 1988; Norris, 1991*a*; McShea, 1994; Arnold, Kelly & Parker, 1995).

Gould (1997) suggested that the body of evidence that supports Cope's Rule may be the result of a sampling bias and other problems. Many studies have focussed on short time scales (Gingerich, 1980; McKinney, 1986; Jablonski, 1997), small sample populations (Gingerich, 1980; McKinney, 1986; McNamara, 1990) and have failed to identify ancestor-descendant pairs from individual evolutionary lineages for direct comparison (Norris, 1991*a*; McShea, 1994; Jablonski, 1997). Gould further suggested that much of the supporting evidence has resulted from a "search for the expected" and that the most appropriate method for establishing the validity of Cope's Rule would be to "study all lineages within large clades with excellent data over substantial geological time" (Gould, 1997 pp. 199). Unfortunately much of the fossil record is too poor to support this approach because it requires knowledge of a reliable species-level phylogeny, including the identification of a sufficient number of lines of ancestry and descent for a statistically rigorous test.

This study aims to address the validity of Cope's rule by using the Cenozoic macroperforate planktonic foraminifera; the group have an up-to-date species-level phylogeny (Chapter 2) and a species-level fossil record at least as good as the genus-level records of the best-preserved macroinvertebrate groups (Aze *et al*., 2011 See Chapter 4) which can be readily sampled using ocean core material. Schmidt *et al*. (2004*a*) produced the largest empirical study focussing on changes in body size of the Cenozoic planktonic foraminifera; the study found that overall body size had increased over the last 65 million years. Arnold, Kelly & Parker (1995) assessed the mechanistic drivers of body size changes and the implication for explaining Cope's rule using evidence from the Cenozoic planktonic foraminifera; the authors concluded that when statistical biases were accounted for there was no support for Cope's rule. Advantages of increased body size have been suggested to increase ability to capture prey and avoid being predated upon, to provide a greater surface area to harbour a greater number of algal symbionts and increase reproductive success. Conversely larger size may be a disadvantage for other biological processes such as speciation; Arnold *et al*., (2004) suggest that smaller bodied forms have shorter generation times which facilitates a more rapid evolutionary response to ecological stress.

1.2 Cenozoic macroperforate planktonic foraminifera

1.2.1 Introduction

Planktonic foraminifera are unicellular biomineralising marine zooplankton that range from tropical to polar latitudes (Bé, 1977; Hemleben, Spindler & Anderson, 1989). They are most abundant and diverse in the upper mixed layer of the ocean where they commonly predate on larval arthropods and other plankton. Some species specialize in living at depth below the photic zone, typically grazing on sinking phytodetritus. Many upper-ocean forms host photosynthesising algal symbionts (see review in Hemleben *et al*., 1989). The cell is largely encased in a calcium carbonate test, i.e. 'shell', beyond which a pseudopodial network is commonly extended for feeding. The tests have very

diverse morphologies with varying degrees of ornamentation. There are 45 morphologically distinct species with vast geographical distributions in the modern oceans (Hemleben *et al*., 1989). The majority of modern (36 out of 45) and Cenozoic fossil planktonic foraminifera belong to the Superfamily Globigerinacea, which is thought to be a monophyletic clade having the most recent common ancestor in the Lower Maastrichtian, approximately 70 Ma although basal Globigerinacea clades extended back at least to the Aptian 124.5-112 Ma (BouDagher-Fadel, 1996). Only two species of macroperforate planktonic foraminifera are believed to have survived the end-Cretaceous extinction event 65 Ma, *Hedbergella holmdelensis* and *H. monmouthensis* (Olsson *et al*., 1999). During the following 65 million years, over 300 different morphospecies apparently descended from these two (Olsson *et al*., 1999).
Planktonic foraminifera, along with other types of biomineralising planktonic organisms, contribute significantly to the material deposited on the sea floor and their tests are extremely abundant in biogenous sediments such as pelagic clays and oozes (Seibold & Berger, 1993). The steady accumulation of such sediments, particularly in stable settings, makes it common for millions of years of evolutionary history to be captured in a single place, and for morphospecies to be preserved continuously throughout their existence. Many such sites have been drilled by the Deep Sea Drilling Project (DSDP) and its successors the Ocean Drilling Program (ODP) and Integrated Ocean Drilling Program (IODP) in all the world's oceans and across a wide range of latitudes and environments. Due to continuing IODP work, and further study of geological sections now exposed on land, recovery of additional material will continue to enhance the already excellent geographical and stratigraphical record of this group. Their fossil record is so well documented and its timescale so well established that species can be sampled at will from more or less any time in their history. The resolution of this record, using material from multiple locations, can be as good as 0.02 million years if orbital cycles can be recognised, permitting high-resolution macro and microevolutionary analyses and palaeoclimatic reconstruction (Cifelli, 1969; Zachos *et al*., 2001).

Planktonic foraminifera have often been used as biostratigraphic markers or to provide geochemical proxies of oceanic and atmospheric temperatures and chemistry. Their use as biostratigraphic zone fossils means that particular attention has been paid to the dates of first and last occurrences of species in the fossil record; their use as environmental indicators means that much information on the life habitats of species and their changing environments has been obtained directly from geochemical analysis of their tests (e.g. Coxall *et al*., 2007; Pearson & Wade, 2009). The use of stable isotopes as a proxy for sea-water temperature was pioneered by Emiliani (1954), who demonstrated that the relative depth habitats of various species in a fossil assemblage could be reconstructed from their stable isotope ratios. Subsequent studies have elucidated the depth habitats of many Cenozoic species, including extinct forms for which there is no observational evidence (Pearson, 1998*a*). Stable isotope and trace metal analysis of foraminiferal calcite has been used in the construction of long-term climate records that highlight important periods in the development of Earth's climate system, such as the onset of glaciation at the Eocene-Oligocene transition approximately 34 Ma (Coxall *et al*., 2005; Lear *et al*., 2008) and the global climatic maximum during Paleocene-Eocene Thermal Maximum (PETM) approximately 55 Ma (Zachos, Dickens & Zeebe, 2008).

The combination of relatively precise dating and detailed records of global climate change throughout the Cenozoic (e.g. Zachos *et al*., 2001, 2008; Lear, Elderfield & Wilson, 2000) provides the means to understand the evolutionary response of planktonic foraminifera to abiotic drivers and address the effects of environmental change on biodiversity (e.g. Wei & Kennett, 1988; Schmidt, Thierstein & Bollmann, 2004; Allen *et al*., 2006). The group has also been a testing ground for other macroevolutionary theories such as Van Valen's Law of constant extinction (Arnold, 1982; Pearson, 1992, 1995; Doran *et al*., 2006) and Cope's Rule of size increase through time (Arnold, Kelly & Parker, 1995; Webster & Purvis, 2002). Detailed morphometric analyses have provided evidence of both phyletic gradualism (e.g. Malmgren & Kennett, 1981) and abrupt speciation (Hull & Norris, 2009).

As in other plankton groups, however, there is also significant cryptic genetic diversity (De Vargas *et al*., 1999; Darling *et al*., 2003; Darling & Wade, 2008). During the past 20 years, molecular analysis of extant planktonic foraminifera has provided increasing evidence of significant 'cryptic speciation' that is not easily identifiable though morphological inspection. New evolutionary relationships have been hypothesised for the group using sequences of a single gene in small subunit ribosomal DNA (SSU rDNA). Examples of inferred cryptic speciation include *Orbulina universa* (three distinct types: de Vargas *et al*., 1999) and *Globigerinella siphonifera* (two types: Huber, Bijma & Darling, 1997; seven types: Darling & Wade, 2008), and the right-coiling

Neogloboquadrina pachyderma and the left-coiling *N. incompta* which were thought to be one species prior to genetic analysis (Darling *et al*., 2004, 2006). The existence of such deeply diverged cryptic genotypes suggests that the traditional, strictly morphometric approach underestimates biodiversity (Darling & Wade, 2008).

The discovery of multiple genetic types has prompted detailed re-examination of the calcite tests to discover more about foraminiferal biology. In the cases outlined above (and others in the literature: Darling & Wade, 2008) these studies have highlighted the significance of sometimes subtle morphological differences when delimiting species, such as, for example, test wall porosity in both *Orbulina* (Morard *et al*., 2009) and *Globigerinella* (Huber, Bijma & Darling, 1997) and coiling direction in *Neogloboquadrina* (Darling *et al*., 2006). The genetic studies on planktonic foraminifera emphasize the benefits of considering the ecology (de Vargas *et al*., 1999; Darling *et al*., 2004, 2006) and biogeography (de Vargas *et al*., 1999; Darling, Kucera & Wade, 2007; Aurahs *et al*., 2009) of organisms when applying palaeontological species concepts. The genetic work does not demand unilateral abandonment of traditional palaeontological species concepts; integrating both sorts of data with ecological information is likely to yield the most comprehensive understanding of any group's evolutionary history (Dayrat, 2005; Will, Mishler & Wheeler, 2005).

1.2.2 Modern planktonic foraminifera and the Tropical Temperature History during Paleogene GLObal Warming (GLOW) Events cruise

'GLOW' was a survey cruise of the SW Indian Ocean on board the Dutch research vessel *Pelagia* (Royal NIOZ) aimed at gathering sufficient seismic and stratigraphic information to support an International Ocean Drilling Program (IODP) full proposal for drilling in the area (Wade *et al*., 2010). The cruise provided a timely opportunity to study tropical planktonic foraminiferal ecology and size in core top and sediments.

(A) Biostratigraphy

To accompany the seismic analysis of the area, a number of box and piston cores were taken where sediments outcropped at the sea floor to provide age constraints on seismic reflectors. Sites were initially box cored and if fossil material was not retrieved then a piston core was employed to penetrate through the overlying recent surface veneer.

Samples were washed over a 63 micron sieve and dried at 40°C in an oven. These were analysed for index species and dated biostratigraphically using an up-to-date compendium of first and last occurrences (Wade *et al*., 2011). A large number of Pleistocene samples with beautiful tropical assemblages were recovered. Figs 1.1, 1.2 and 1.3 illustrate some of the diversity in the assemblages collected from the sea floor that ranged in age from the Recent to Middle - Upper Miocene (8.58 – 9.82 Ma) (see Plate 1.1 for images of the sampling techniques used onboard RV *Pelagia*).

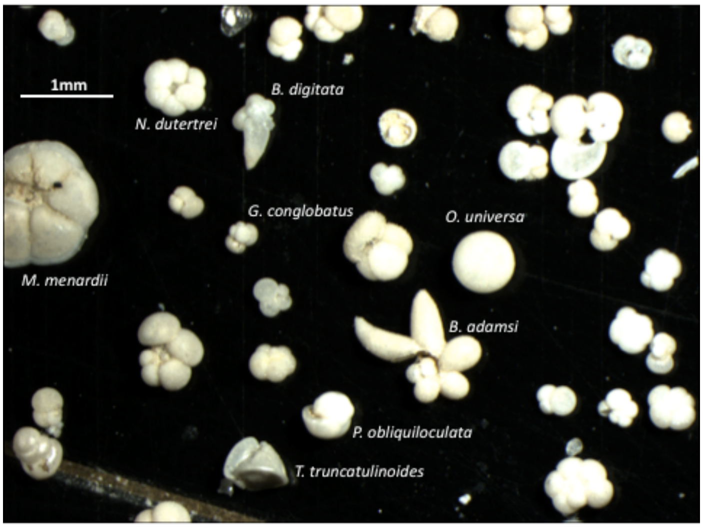


Figure 1.1 Recent planktonic foraminifera from the GLOW 7 box core. The assemblage includes *Menardella menardii*, *Neogloboquadrina dutertrei*, *Beella adamsi*, *Beella digitata, Globoquadrina conglobatus, Orbulina universa, Pulleniatina obliquiloculata* and *Truncorotalia truncatulinoides*.

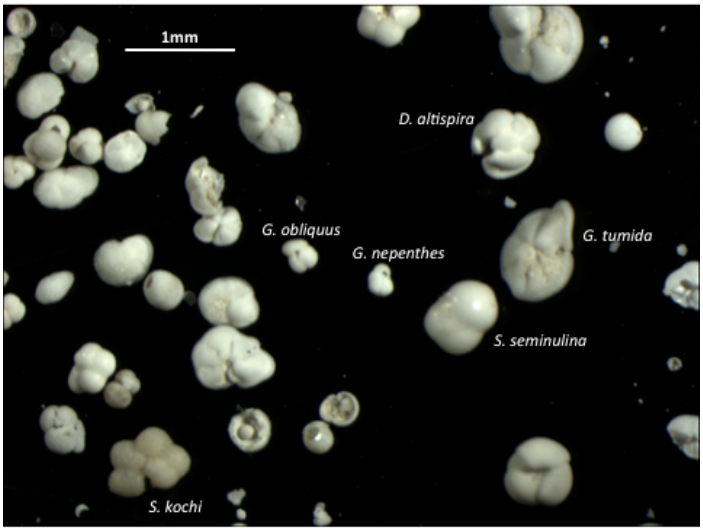


Figure 1.2 Planktonic foraminifera from GLOW 13, assigned to planktonic foraminifera Biozone PL1 (Age 5.54 - 5.82 Ma). The assemblage includes *Globigernoides obliquus, Spharoidinellopsis seminulina, Globoturborotalita nepenthes, Globorotalia tumida and Dentoglobigerina altispira.*

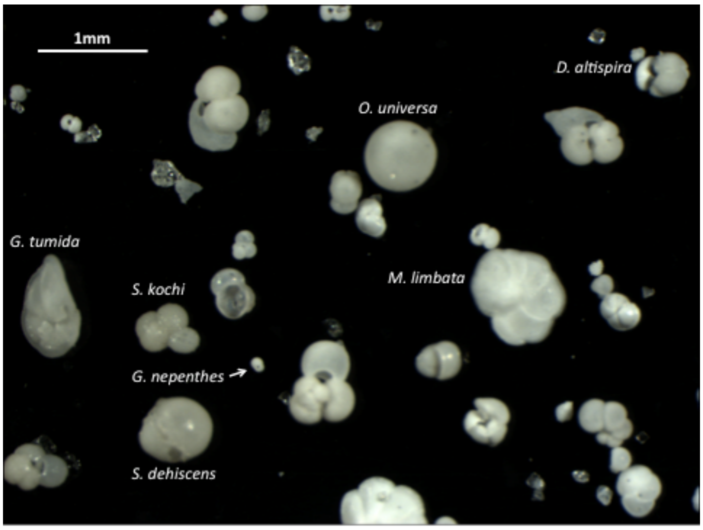


Figure 1.3 Foraminifera from the GLOW 22 Piston Core cone, assigned to planktonic foraminifera Biozone PL1 (4.39 - 5.49 Ma). The assemblage includes *Globoturborotalita nepenthes*, *Globorotalia tumida, S. kochi*, *Sphaeroidinella dehiscens* and *D. altispira.*

(B) Plankton nets

At four localities plankton nets were taken to provide samples of living planktonic foraminifera for DNA analysis (not part of this study). A funnel shaped net with a circular opening of 55 cm and a mesh size of 200 micrometres (µm) was lowered vertically to a depth of 500 m and hauled in with a speed of 0.5 m per second while the ship was at station.

The planktonic material in the net was washed down into a removable pot (cod end) at the end and was kept in sea water to prevent desiccation. It was observed that the plankton material clumped together in the seawater in gelatinous masses which was sub-sampled into Petri-dishes and studied and picked under microscopes for up to 3 hours after collection in order to keep the living foraminifera DNA at an optimum condition for later extraction. Individual specimens were identified using standard reference works (e.g. Kennett & Srinivasan, 1983; Hemleben *et al*., 1989). Observation of living plankton provided the opportunity to study the living planktonic foraminifer cells and make qualitative assessments of the differences between assemblages in the water column and those found on the sea floor. Of particular interest was the observation of spinose specimens floating in the Petri dishes that still had all of their spines attached interwoven with their pseudopodial network extending from their tests (See Plate 1.2 A, B and G). .

Assemblages at each station were similar; the most abundant spinose species collected were *Globigerinella siphonifera*, *Globigerinoides trilobus*, and *Orbulina universa*. Also common were *Hastigerina pelagica*, *Candeina nitida*, *Globigerinoides conglobatus*, *G. ruber*, and *Globigerinella calida*. Among non-spinose species, specimens of *Neogloboquadrina dutertrei*, *Pulleniatina obliquiloculata*, *Hirsutella hirsuta*, *H. scitula*, *Truncorotalia crassaformis* and *Menardella menardii* were recorded. Species present in the plankton nets were also found in abundance on the sea floor with the exception of *Hastigerina pelagica*. Although common in the plankton nets this species was not readily found in the sediment, occasional recognisable fragments were found (other than two sites where whole tests were found in the top layer of sediment) and it is proposed that these specimens do not readily preserve due to the fragility of their thin tests.

Plate 1.1 Photographs illustrating some of the scientific operations onboard RV Pelagia during the GLOW cruise. **(A)** The box core on deck ready to be lowered over board for sampling. **(B)** The box core prior to sub-sampling. **(C)** The box core sub-sampled with 4 plastic tubes. The sub-sampled cores were then sent for storage at NIOZ. **(D)** The clay sediments rich made for messy work, but also facilitated the exquisite preservation of calcareous microplankton. **(E)** The piston core being lowered into the ocean by a winch off the side of RV Pelagia. **(F)** The piston core after sampling the seafloor being cut into sections for storage. **(G)** The plankton net being hauled in and washed through. The catch was collected in the cod end (the red container). **(H)** The material collected was sub-sampled and analysed under a microscope, all living foraminifera were extracted for DNA study. **(I)** Live planktonic foraminifer specimens being transferred into sample vials and fixed with a measured aliquot of buffer. Photos A, B, and C taken by Dr Bridget Wade and D, E, F, G, H and I taken by Heather Birch.

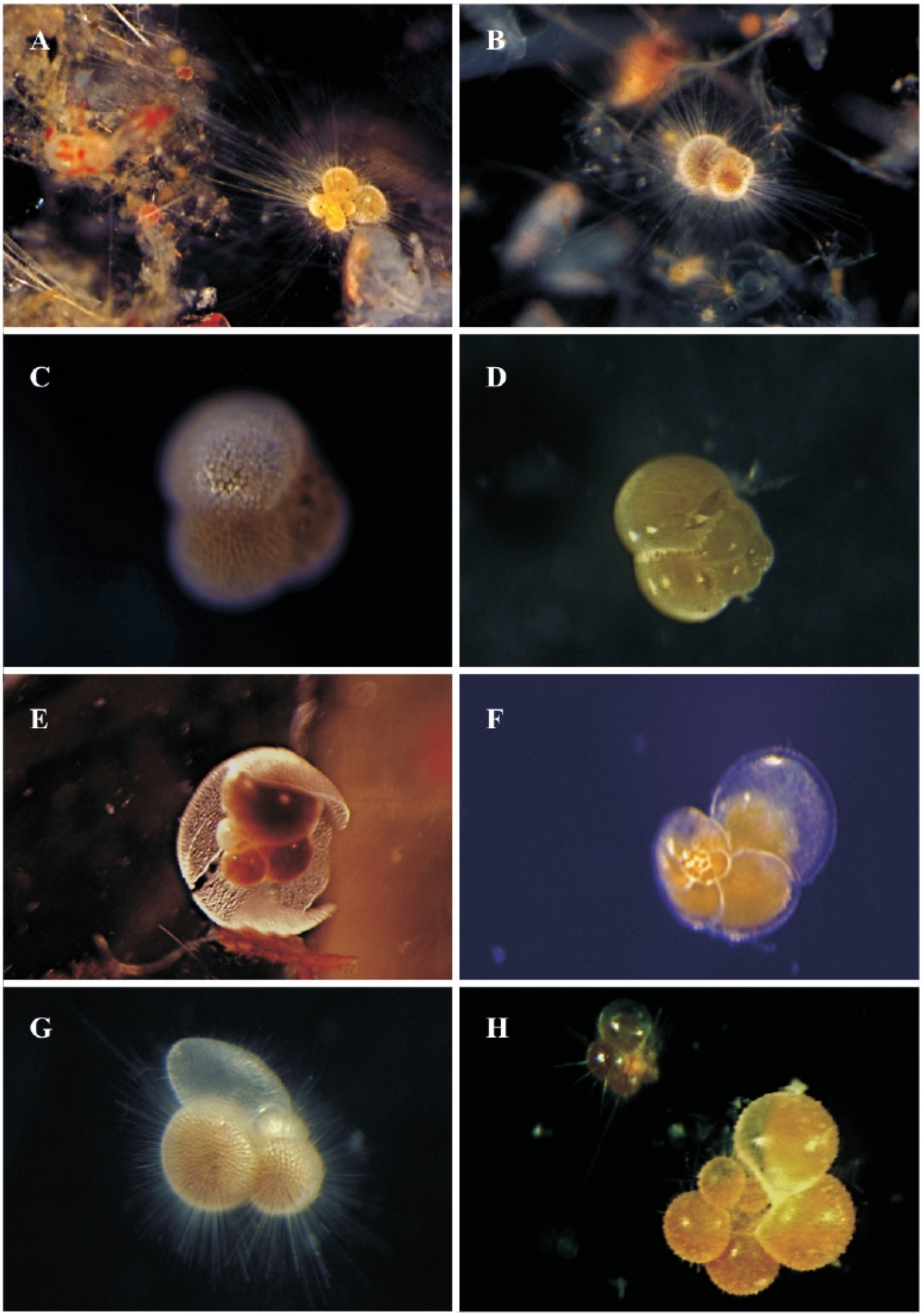


Plate 1.2 Planktonic foraminifera from the GLOW plankton nets. Species collected included (A) *Globigerinella siphonifera.* (B) *Globigerinoides trilobus.* (C) *Globoquadrina conglomerata*? (D) *Candeina nitida.* (E) *Orbulina universa,* broken showing earlier chambers. (F) *Menardella menardii.* (H) *G. siphonifera* (foreground) with *Hastigerina pelagica* (background). These examples were captured at GLOW sites 1 (A – C, F), 13 (H) and 15 (D, E, G). Images have been re-scaled for visual effect and no scale bars are available (Plate taken Kroon *et al*., Unpublished).

1.2.3. History of Cenozoic planktonic foraminiferal taxonomy and phylogeny

Planktonic foraminifera, both fossils and living, have a long history of taxonomic work and revision. This work has, with hindsight, proceeded in several phases prompted by the appreciation of the usefulness of particular species and groups of species in biostratigraphy, by technological advances that opened up new sets of characters for study, and by changes in systematic philosophy and practice. Table 1.1 summarises major developments in planktonic foraminiferal research since their discovery in 1826.

Table 1.1 Major themes and progress in the history of taxonomic and phylogenetic planktonic foraminiferal research

Date	Major themes and progress	Reference
1826 - 1839	Planktonic foraminifera were described from beach sands and classified as cephalopods.	d'Orbigny (1826, 1839 *a*, *b*, *c*).
1839 - 1899	Further discoveries of planktonic foraminifera in deep sea sediments and rocks. The planktonic nature of several species became widely accepted after dredging reports from the *HMS Challenger* Expedition (1872-1876).	Ehrenburg (1861, 1873); Carpenter *et al*. (1862); Parker & Jones (1865); Gümbel (1868); Hantken (1875); Brady (1884); Murray & Renard (1891)
	The utility of planktonic foraminiferal distributions as climate and water mass indicators was discovered.	Murray (1897)
1900 - 1911	First investigations into planktonic foraminiferal biology were published.	Rhumbler (1901, 1911)
1912 - 1949	Detailed systematic research into planktonic foraminifera flourished when their use for stratigraphic correlation of rocks became appreciated, particularly due to the expansion of oil exploration in the early 20th century. A relatively simple taxonomic approach developed, dividing genera by major features of test morphology and apertural position.	Cushman (1927 *a*, *b*); Cushman (1933); Finlay (1939, 1940); Subbotina (1947)
1950 - 1968	Stable isotope analysis of foraminiferal calcite was first used to infer oceanic palaeotemperatures and species depth habitats.	Emiliani (1954, 1955)
	Worldwide study produced detailed investigations into global distributional patterns.	Phleger (1951); Parker (1954, 1960, 1962); Sigal (1958); Bradshaw (1959); Bé (1959, 1960); Boltovskoy (1964, 1966 *a*, *b*); Lipps (1966); Cifelli (1969)

	Major taxonomic synthetic works produced the first phylogenetic trees; evolutionary convergence was recognised and some pre-existing genera were split.	Bronnimann (1952); Subbotina (1953); Bolli (1957 *a*, *b*); Loeblich *et al*. (1957); Morozova (1957, 1960, 1961); Banner & Blow (1959); Hofker (1959); Leonov & Alimarina (1960); Alimarina (1962, 1963); Blow & Banner (1962); Wade (1964); Berggren (1968) McGowran (1968)
1969 - 1979	From 1969 the Deep Sea Drilling Program began to provide many new relatively continuous sediment records from throughout the Cenozoic. The use of scanning electron microscopes (S.E.M) from the late 1960s led to rapid advancements in the understanding of the phylogenetic evolutionary history of planktonic foraminifera. Some workers began to recognise the significance of wall ultrastructure for identifying phylogenetic affinity and began developing a more natural higher taxonomy.	El Naggar (1971); Jenkins (1971); Postuma (1971); Steineck (1971); Bandy (1972, 1975); Collen & Vella (1973), Fleisher (1974); Stainforth *et al*. (1975); Steineck & Fleisher (1978); Blow (1979)
1980 - 1989	Ongoing ocean drilling and widespread use in the exploration industry led to significant further advances in the synthetic taxonomy and biostratigraphy of planktonic foraminifera.	Saito, Thompson & Breger (1981); Srinivasan & Kennett (1981*a*, *b*); Kennett & Srinivasan (1983); Bolli, Saunders & Perch-Neilsen (1985); Cifelli & Scott (1986); Fordham (1986); Wei (1987); Stanley, Wetmore & Kennett (1988).
1990 - present	Establishment of taxonomic working groups affiliated to the International Commission on Stratigraphy produces a systematic revision of all fossil planktonic foraminifera based on S.E.M. investigation of all available original type material, with a strong emphasis on wall ultrastructure analysis to delimit higher taxonomic groupings	Chaproniere (1992); Pearson (1993, 1998a); Spezzaferri, (1991, 1994); Chaisson & Pearson (1997); Olsson *et al*. (1992, 1999); Pearson *et al*. (2006).
	Extraction and analysis of foraminiferal genetic material provides a new method of taxonomic identification and evidence of cryptic speciation which highlights the importance of integrating molecular and traditional morphological taxonomic approaches for the most comprehensive understanding of planktonic foraminiferal evolution.	Pawlowski *et al*. (1994a,b); Pawlowski *et al*. (1996) Darling *et al*. (1996 *a*, *b*, 1997, 1999, 2004, 2006, 2007); De Vargas & Pawlowski (1998); De Vargas *et al*. (1999); Pawlowski & Holzmann (2002)

1.2.4. Summary

Planktonic foraminifera provide a model system for macro and microevolutionary research. There is a mature taxonomy and well documented phylogenetic framework for the group, information on their life habits and ecology is available with direct sampling of living material from the open ocean and through analysis of the isotopic composition of fossil material. They have an exceptional fossil record and the understanding of their genes is ever improving. However, a large phylogeny based on fossil data is valuable as a hypothesis of the evolutionary relationships of planktonic foraminifera that can be tested with molecular data (though genetic data may be unable to resolve patterns of rapid branching in the distant past: Rokas *et al*., 2005). Additionally, phylogenetic trees constructed using distinct single genes (collected in this instance from restricted sampling locales in relation to the vast geographical distribution of many of these species) can imply very different phylogenetic structures that bear little resemblance to the underlying species tree (Maddison, 1997). Large-scale SSU rDNA phylogenies on the scale of the fossil one presented within this thesis have not yet been constructed due to incomplete sampling and the simple fact that most included species are extinct.

1.3. Aims

- To produce a species level synthesis phylogeny of all Cenozoic macroperforate planktonic foraminifera morphospecies and to convert to the morphospecies phylogeny into an evolutionary lineage phylogeny.
- To analyse the lineage phylogeny in a macroevolutionary context, focussing on absolute diversity, diversification rate, extinction and speciation trends with reference to the distinct morpho- and eco-groups to which the lineages are assigned.
- To test for Cope's rule in Cenozoic macroperforate planktonic foraminifera using a random sampling protocol based the new lineage phylogeny and revisit the global sediment record for appropriate samples. The random sample negates the problem identified by Gould (1997 pp.199) as the "search for the expected".

The thesis is divided into 5 chapters and a précis for the fieldwork and training involved in the project is detailed below.

1.4. Account of the project

The following PhD thesis was produced during the course of a tied PhD studentship that was part of a collaborative project between Imperial College and Cardiff University titled *Macroevolution of Cenozoic planktonic foraminifera* under the direction of Prof. Andy Purvis (Imperial College) and Prof. Paul Pearson (Cardiff University) (NERC grant NE/E015956/1).

As a tied project the studentship required the completion of a species level synthesis phylogeny of all Cenozoic macroperforate planktonic foraminifer morphospecies. This phylogeny and the derived lineage phylogeny would form the basis of a range of macroevolutionary studies to be carried out by the group, including a size analysis study to test for Cope’s rule which was the remaining focus of this PhD. It was initially anticipated that the construction of the phylogenies would take 6 months to one year. This was an underestimate, although a workable tree was produced in this time the final construction of the phylogeny came after 2 years.

The first year of the project focussed upon collection and synthesis of the taxonomic and phylogenetic work required to construct the phylogenies. The first year also involved additional training in the form of a 10-day sampling trip to the Tanzania Petroleum Development Corporation (TPDC), Dar-Es-Salaam, Tanzania during November 2007. This visit provided hands on experience sampling and washing core material for micropalaeontological analysis. During February 2008 I attended the three-week Generalised Linear Modelling course at Imperial College aimed at providing a basic overview of statistical programming using R. I was awarded a place on the Paleobiology Database summer school in Analytical Paleobiology (June-July 2008) that was hosted by Dr John Alroy at the National Centre for Ecological Analysis and Synthesis (NCEAS), Santa Barbara, California, U.S.A. It was a six-week intensive course focussing on programming in R for palaeoecology, diversity analysis, morphometrics, phenotypic evolution and phylogenetics.

The second year of my PhD research continued to focus upon the compilation of taxonomic and phylogenetic data for the phylogenies which was followed by the derivation of an evolutionary lineage phylogeny from the initial morphospecies phylogeny. In February and March 2009 I participated in a research cruise titled “Tropical Temperature History during Paleogene GLObal Warming (GLOW) Events” in the South-West Indian Ocean (Chief Scientist Prof. Dick Kroon). The cruise was a survey cruise for a potential Integrated Ocean Drilling Program (IODP) voyage and involved box and piston coring, biostratigraphic dating of sediments, collection of living planktonic foraminifers for DNA extraction and seismic and multibeam surveys of the sea floor. The remainder of my second year was spent finishing the phylogenies and starting the organisation of samples required for the size analysis study.

The third year of my PhD was spent wholly in Cardiff; the phylogenies were finished and submitted for publication to *Biological Reviews*: A phylogeny of Cenozoic macroperforate planktonic foraminifera from fossil data (Aze *et al*., 2011). Collaboration with the wider team has led to other manuscripts including an analysis of the relative role of environmental and biotic changes driving the evolutionary pattern of the group (Ezard *et al*., 2011) which is not part of this study. The remainder of my PhD was spent collecting, imaging and measuring the material for the size analysis study.

2. Morphospecies and lineage phylogenies of the macroperforate Cenozoic planktonic foraminifera

2.1 Introduction

The fossil record has long been a major source of evidence for the study of evolution (as summarised by Simpson, 1953; Gould, 2002; Benton, 2009) and is a rich source of information about past environments and biodiversity. Changes in diversity can be tracked and correlated against palaeoenvironmental data to address questions of fundamental biological importance: what happens to global or local biodiversity in response to rapid climate change? Is the world full of species? Are speciation and extinction rates diversity-dependent? Is the likelihood of speciation dependent on species age? How do character change, speciation and extinction combine to cause an evolutionary trend?

The fossil record presents two kinds of problem for studies of macroevolutionary dynamics. The first is that the fossil record contains biases that result from the way in which the record is deposited and sampled. Some taxa, locations and periods of geological time are more thoroughly sampled than others and this lack of uniformity produces an observed diversity of fossils that is not necessarily a faithful reflection of underlying diversity patterns (McKinney, 1991; Paul & Donovan, 1998; Kidwell & Holland, 2002). Much research effort has been directed at filtering out these biases to produce a more accurate picture (Foote, 1992; Smith, 2007; Alroy *et al.*, 2008; Rivadeneira, Hunt & Roy, 2009) This is one reason why a major recent research effort in the palaeobiological community has been the construction of large occurrence-based databases, such as the Paleobiology Database (http://www.paleodb.org/) and NEPTUNE (services.chronos.org/databases/NEPTUNE/index.html). These help to highlight parts of the fossil record that are particularly well represented and those that are not.

The second kind of problem is that paleobiological taxonomic concepts are typological: due to the absence of genetic information specimens are assigned to species or higher taxa on the basis of morphological characteristics alone and ‘species’ in the fossil record may be either more or less inclusive than the underlying evolutionary species (Forey *et al.*, 2004). Some extant morphologically delimited species apparently contain multiple genetic species; detailed investigation often, but not always, reveals diagnostic morphological differences (Jackson & Cheetham, 1990; Darling & Wade, 2008).

A related issue arises when specimens from different points in time along a single evolving lineage (i.e. an ancestor-descendant series of populations) are assigned to different named forms. This is a common problem when dealing with fossil groups that have particular biostratigraphic value, because morphologically intergrading forms tend to be arbitrarily split into constituent morphospecies to provide more accurate means for correlating and dating rocks. When this happens, taxa can appear in the fossil record without any cladogenesis ('pseudospeciation') and can disappear without any extinction ('pseudoextinction') (Simpson, 1951; Stanley, 1979; Fordham, 1986). This problem becomes more obvious as the fossil record of a study system approaches completeness. A very complete record can provide a solution: if morphospecies are seen to intergrade through time, they can be assigned to the same evolutionary species (Simpson, 1951; Fordham, 1986; Pearson, 1998*a*).

Macroevolutionary dynamics are increasing explored using time-calibrated (usually molecular) phylogenies of extant taxa. This approach can overcome the shortcomings of a poor fossil record but assumptions are made about the constancy of per-lineage rates of speciation and extinction through time (Nee, May & Harvey, 1994). It has become apparent that there are several limitations of the molecular phylogenetic approach, estimates of underlying rate parameters are biased through inclusion of only extant species, the choice of diverse clades to analyse and the incorrect assumption that all contemporaneous species have the same chances to diversify (Nee *et al*., 1994; Ricklefs, 2007; Purvis, 2008; Rabosky & Lovette, 2008; Rabosky, 2010). More generally, the absence of direct information from fossils can make it hard to differentiate among very different scenarios, especially early in a clade's history (Harvey *et al*., 1994; Rabosky & Lovette, 2008).

The ideal study system for macroevolution would be a comprehensive phylogeny of all extant and extinct evolutionary species within a clade that combines morphological, molecular and stratigraphic data (Purvis, 2008; Benton, 2009). This is only possible with an exceptionally rich and well-studied fossil record such as is available from the biomineralising ocean plankton. Macroperforate planktonic foraminifera are an extremely abundant and cosmopolitan group. Their excellent preservation potential, combined with the relatively complete and continuous sedimentary successions in which they are found make species-level studies possible. They have one of the best fossil records of any group, especially throughout the Cenozoic Era [~65 Million years ago (Ma) to present].

This chapter summarises the recently published Aze *et al*. (2011) and is a synthesis of previous work on the taxonomy and relationships of Cenozoic macroperforate planktonic foraminifera into a phylogeny of all discernible evolutionary lineages, which can then be used as a model system for macroevolutionary research and tested against independent, molecular data.

2.2. Terminology

Mayr (1942, p.120) defined biological species as 'groups of actually or potentially interbreeding natural populations which are reproductively isolated from other groups'. When applying species concepts to fossil data workers typically apply the rules laid out in the *International Code of Zoological Nomenclature* (ICZN, 1999). This means that populations are assigned to species on the basis of morphological similarity to their respective holotypes in the absence of information on the behaviour of the species in question. A species that is defined with reference to a specific holotype and which represents a point in morphospace is a typological species. Species can be also be defined with more flexibility as a general morphology representing a sector of morphospace that includes the type; such a species is referred to as a morphological species (Smith 1994; Forey *et al*., 2004; Pearson *et al*., 2006). The species-level taxa, named using Linnaean binomial nomenclature, are regarded as morphospecies in this work and include typological and morphological species.

The morphospecies phylogeny presented in this work depicts the stratigraphic ranges and hypothesised evolutionary relationships of fossil and recent macroperforate planktonic foraminifer morphospecies. Central to the construction of the phylogenies within this work is the concept of an evolutionary lineage (or lineage). Simpson (1961, p.153) regarded the lineage as a single line of descent and described it as 'an ancestral–descendant sequence of populations evolving separately from others with its own unitary evolutionary role and tendencies'; this is also known as an evolutionary species

(Simpson, 1951; Wiley, 1978; Mayden, 1997). According to this concept, the phenotypes displayed by members of an evolutionary lineage may change through time; it is the continuity, rather than the presence of any diagnostic character, that delimits the lineage. Operationally, continuity is inferred from temporal phenotypic dynamics, and different lineages are recognised by disjunctions in phenotypes among specimens from the same time (Fordham, 1986; Mayden, 1997; Pearson, 1993, 1998*a*). Artificial boundaries based on changes in morphology cut through the evolutionary lineages in order to subdivide successive populations. Although these morphological changes may fully intergrade if no partitions were made, completely different fossils would then be classified together (Figure 2.1).

From a biostratigraphic perspective, it is useful to subdivide lineages as finely as possible to achieve the maximum possible stratigraphical resolution. The importance of planktonic foraminifera as biostratigraphic markers means that lineages within the group have been subject to much fine-scale splitting. Consequently many of the morphospecies appear to be intergrading forms belonging to the same lineage as other morphospecies: they do not arise through cladogenesis, and they do not disappear through extinction of any lineage (Fordham, 1986; Pearson, 1993, 1998*a*) (Figure 2.1).

The lineage phylogenies presented here depict only cladogenetic speciation events, with morphospecies merged together into their respective lineages. Therefore, the branches within each lineage phylogeny represent the ranges and relationships of evolutionary lineages though time, rather than the morphospecies (Figures. 2.1 and 2.2). Branches that end at a splitting event (cladogenesis) are non-terminal branches, whereas terminal branches end in extinction. Two versions of lineage phylogenies are presented in this work (Figures 2.3 A, B, see also the Electronic appendix, Part C) correspond to different lineage concepts. The Hennigan species concept (Hennig, 1966; Meier & Willmann, 2000) equates species with internodes, such that species cease to exist either through extinction or through speciation. The evolutionary species concept (Simpson, 1951; Wiley, 1978) differs in recognising the possibility that an ancestral species can persist through a speciation event; the completeness of the foraminifera fossil record makes it possible to assess whether an ancestor persists without apparent morphological change (Figures 2.1 and 2.2).

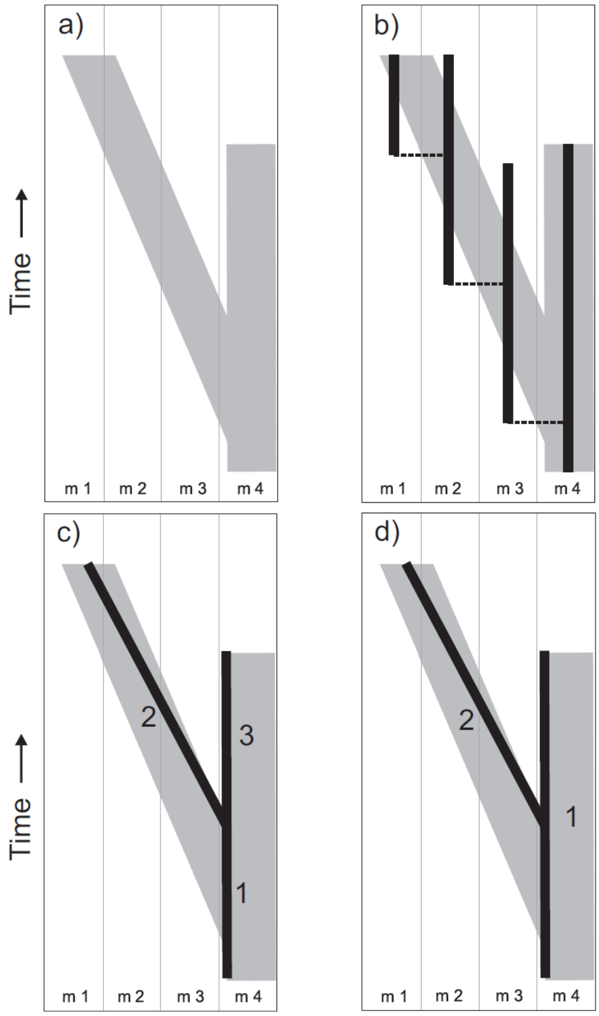


Figure 2.1 A schematic illustration of how morphospecies and lineages are represented on a phylogeny. **(A)** Each panel represents morphospace and the grey boxes within it areas of morphospace occupied by fossil populations. This has been divided by the vertical dashed lines into 4 distinct morphospecies, morphospecies 1 (m 1) to morphospecies 4 (m 4), which are separated from one another on the basis of morphological dissimilarity. (B) An illustration of how the fossil populations would be represented on a morphospecies phylogeny. The solid black vertical lines represent the stratigraphic ranges of the morphospecies and the horizontal dashed black lines represent the inferred evolutionary relationships between them. **(C)** An illustration of how the fossil populations would be represented on a lineage phylogeny using a Hennigian species lineage concept. It highlights the arbitrary nature of the morphospecies concept, the boundaries between morphospecies are defined by taxonomic workers principally to aid biostratigraphic work, but evolutionarily it is clear that the fossils populations illustrated above are fully intergrading and therefore belong to one lineage. Only when there is empty morphospace between populations in multidimensional space can a speciation event be inferred. There are three Hennigian lineages, one internode lineage (1) and two terminal lineages (2 and 3). (D) An alternative 'evolutionary' lineage phylogeny. In this case there are no internode lineages all lineages end in an extinction event. Lineages are permitted to persist through speciation events if there has been no change in morphology between one of the descendant Hennigian species and its ancestor (1 and 3 in C). Consequently there are only two 'evolutionary' lineages rather than three as in C.

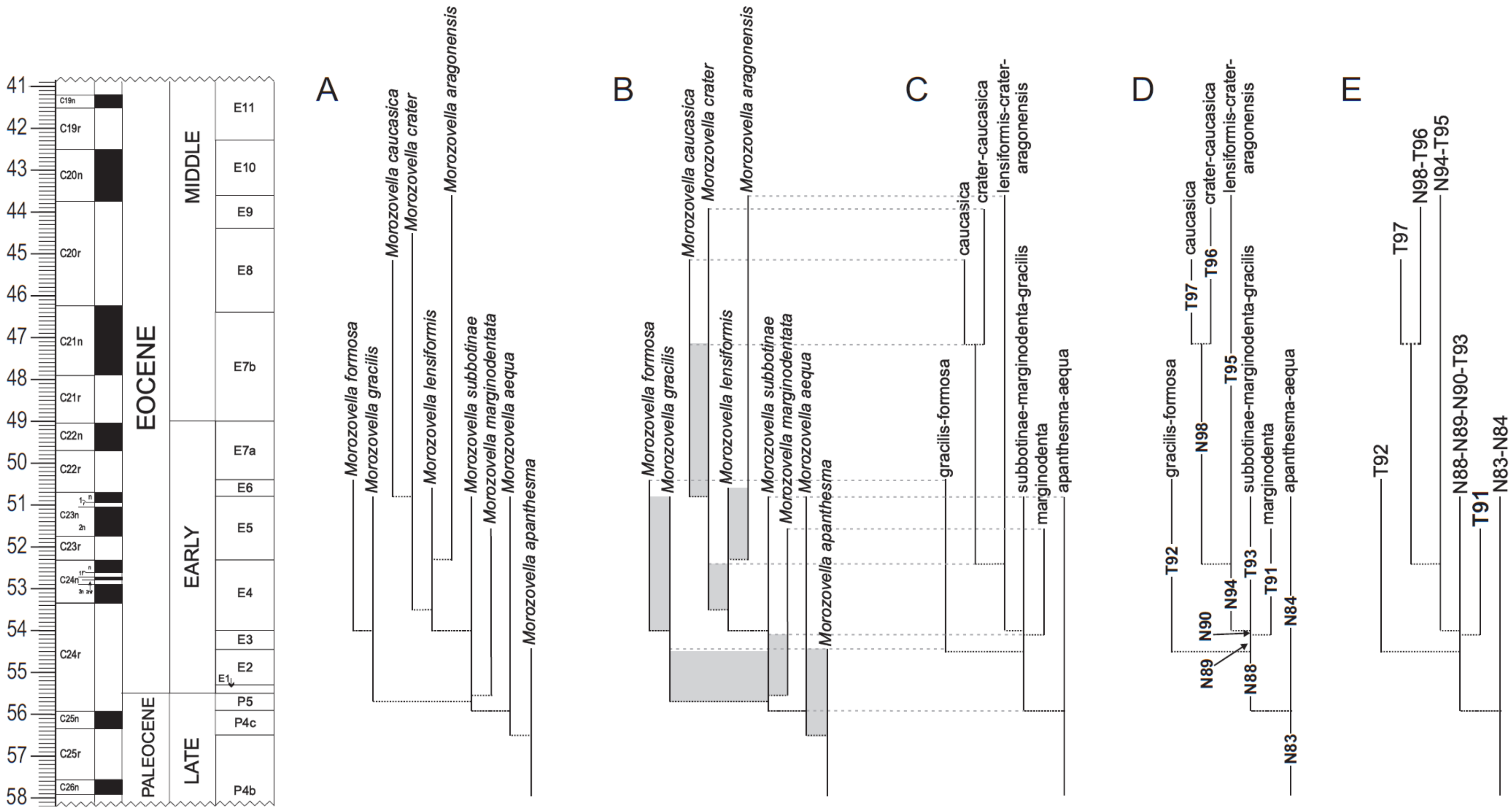


Figure 2.2 An example from this review of how the lineage phylogeny is derived. **(A)** Part of the morphospecies phylogeny of the genus *Morozovella*. **(B)** Morphological intergradation of the morphospecies is indicated by the grey blocks; merging these together removes pseudospeciations and pseudoextinctions. **(C)** The resulting 'evolutionary lineage' phylogeny now illustrates the relationships between lines of descent rather than morphospecies. Note the reduction in the length of many branches and the merging of multiple morphospecies into single branches (the grey dashed lines are included to aid comparison). Cladogenetic events may be bifurcating such as the caucasica and crater-caucasica lineages, or budding as in the rest of the clade. **(D)** Because the Latin binomial names of the morphospecies are no longer applicable, lineages are given unique concise codes. Every internode in the phylogeny is assigned an arbitrary number, prefixed with a 'T' for terminal lineages and 'N' for non-terminal lineages. **(E)** In the resulting lineage phylogeny all numbers that represent one evolutionary lineage (evolutionary lineage according to Simpson, 1951) are grouped together in a chronological sequence at the end of each lineage. The corresponding morphospecies names that are included in these lineages can be found in the Electronic appendix, Part A, columns headed species name and LID.

2.3. Methods and results

2.3.1 A phylogeny of morphospecies

It is common in the literature to depict stratigraphic ranges of morphospecies with connections that denote supposed evolutionary relationships, and the morphospecies phylogeny was derived from literature of this kind (see Tables 2.2 and 2.4). Work synthesising information on standardised taxonomy and phylogenetic relationships was favoured where available. All species that were recognized as a distinct species in at least one major taxonomic work were included in the phylogeny; a degree of subjectivity regarding which species were included was inherent in this approach. Until every single divergence has been resolved by means of quantitative morphometrics at multiple localities on a centennial scale, phylogenetic hypotheses for the whole clade over the entire Cenozoic can only be made by tracing sequences of occurrences of species through strata based on their overall morphological similarity. Where there was conflicting information in the literature, the most up-to-date publications presenting an integrated taxonomy from well-defined stratigraphic sections were favoured. The morphospecies phylogenies for the Paleocene and Eocene were taken directly from the *Atlas of Paleocene planktonic foraminifera* (Olsson *et al*., 1999) and the *Atlas of Eocene planktonic foraminifera* (Pearson *et al*., 2006). We have not included taxa that are recognised on the basis of genetic evidence, such as *N. incompta*, as only a minority of even the extant morphospecies have been investigated in this way. PLANKRANGE (http://palaeo.gly.bris.ac.uk/Data/plankrange.html), an online database of planktonic foraminifera, was used in conjunction with an exhaustive literature search in order to eliminate synonymy. Dates of first and last appearances were converted where necessary to the biozonation timescales of Berggren *et al*. (1995), Berggren & Pearson (2005) and Wade *et al*. (2011). These timescales have been astronomically and paleomagnetically calibrated, and their use will facilitate future revisions of the trees as and when they are updated over the coming years.

Most of the literature underpinning the morphospecies phylogeny used a stratophenetic approach (Gingerich, 1976). The aim of stratophenetics is to reconstruct ancestor-descendant relationships of fossil organisms based on "(1) quantitative assessment of morphological (phenetic) similarity, interpreted within the context of (2) independent evidence of geological age" (Gingerich, 1992, p. 437). Stratophenetics incorporates time when trying to elucidate genealogical relationships (Gingerich, 1992). Phylogenetic hypotheses are also often constructed through cladistics, using synapomorphies (shared derived characters) as evidence of relationship among species (Hennig, 1966; Smith, 1994). Cladistics is particularly valuable for groups with a poor fossil record, where information about ancestor-descendant relationships is limited, but has significant limitations when constructing a phylogeny for large groups with a long history and good fossil record. The cladistic method excludes stratigraphic information and is particularly sensitive to homeomorphy, which is rife within planktonic foraminifera due to widespread temporally distinct convergent evolution (Cifelli, 1969; Banner & Lowry, 1985; Norris, 1991*b*). The over 300 Cenozoic macroperforate morphospecies are identified on the basis of few easily recognisable, discrete morphological characters, and are known for their convergent morphological evolution (Coxall *et al.*, 2007; Norris, 1991); convergence due to a limited repertoire of morphologies leads to 'character exhaustion', resulting in homoplasy eroding the hierarchical signal in character data (Wagner, 2000). Cladistic analyses of planktonic foraminifera suffer from extensive homoplasy, with the most parsimonious relationships sometimes conflicting with stratigraphy (Stewart, 2003). Combined, these factors can make the outcome of cladistic analysis less meaningful than the inferences derived from carefully tracing evolutionary lineages though the sediment record (Pearson *et al.*, 2006).

The resulting stratophenetic morphospecies phylogeny represents sectors of morphospace, and the stratigraphic ranges represent the times in the past when those sectors of morphospace were occupied by living organisms (Pearson 1998*a*). First and last occurrences of morphospecies do not necessarily represent genuine speciation and extinction events because gradual anagenetic evolution can result in the appearance of new morphologies (pseudospeciation); similarly the last occurrence of a morphospecies may be caused by evolutionary transition rather than a real extinction (pseudoextinction) (Stanley, 1979). The resulting morphospecies phylogeny is shown in Figure 2.3.C with detail in Figures 2.4 and 2.5. The phylogenies are available as data and in full-colour plots (Figures 2.7 and 2.8) in the electronic appendix Parts A, B and C, which also contains a full appendix of listing relevant details used in construction of the phylogenies and divergence times between extant lineages.

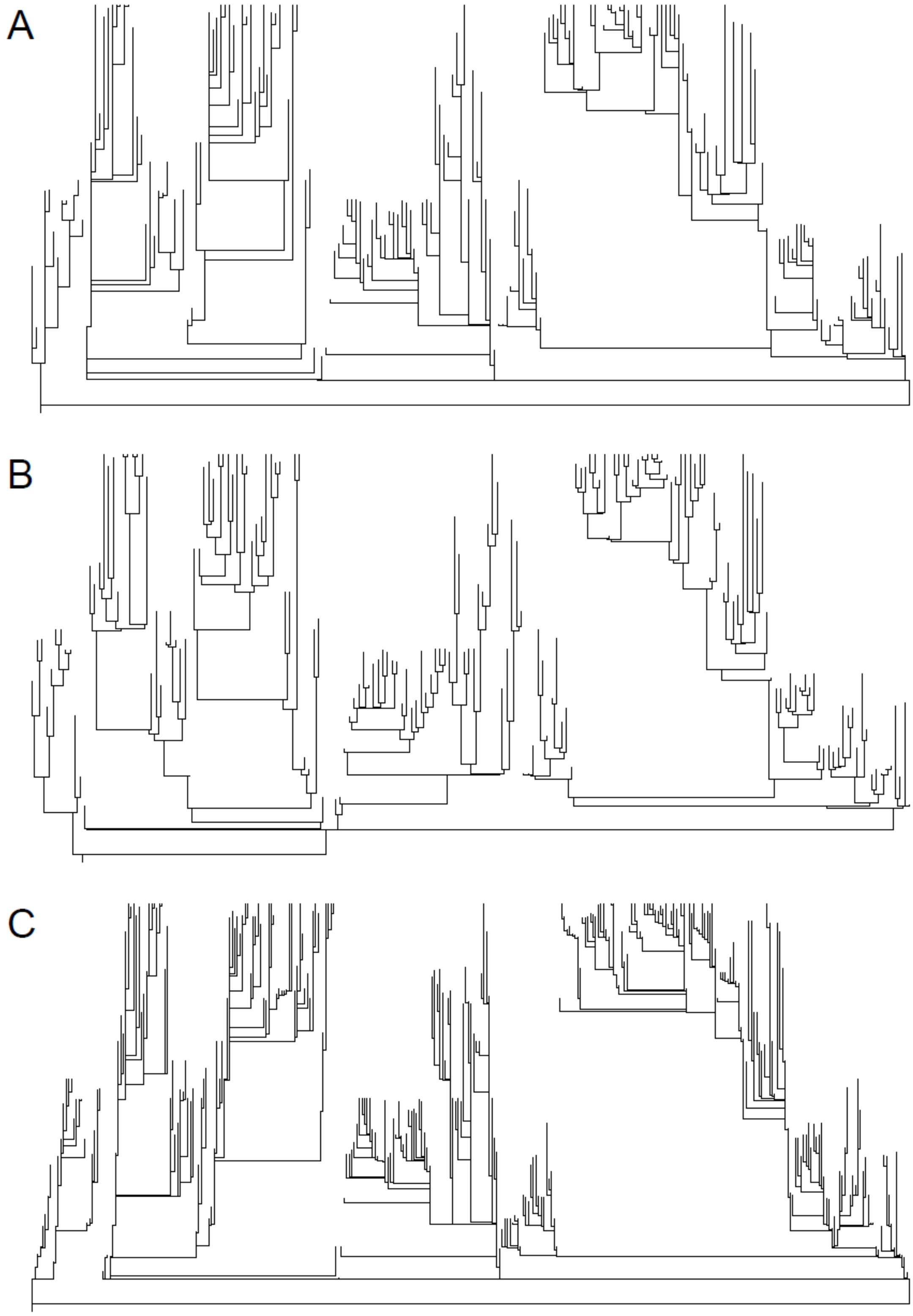


Figure 2.3 A schematic showing the three complete phylogenies arranged similarly. **(A)** Is the evolutionary lineage phylogeny. **(B)** Is the Hennigian lineage phylogeny and **(C)** is the morphospecies phylogeny. Tip and node labels are provided in the Electronic appendix, Part C and via Fig. 8. These figures were drawn using paleoPhylo (Ezard & Purvis, 2009) in the R environment (version 2.10.1, R Development Core Team 2010).

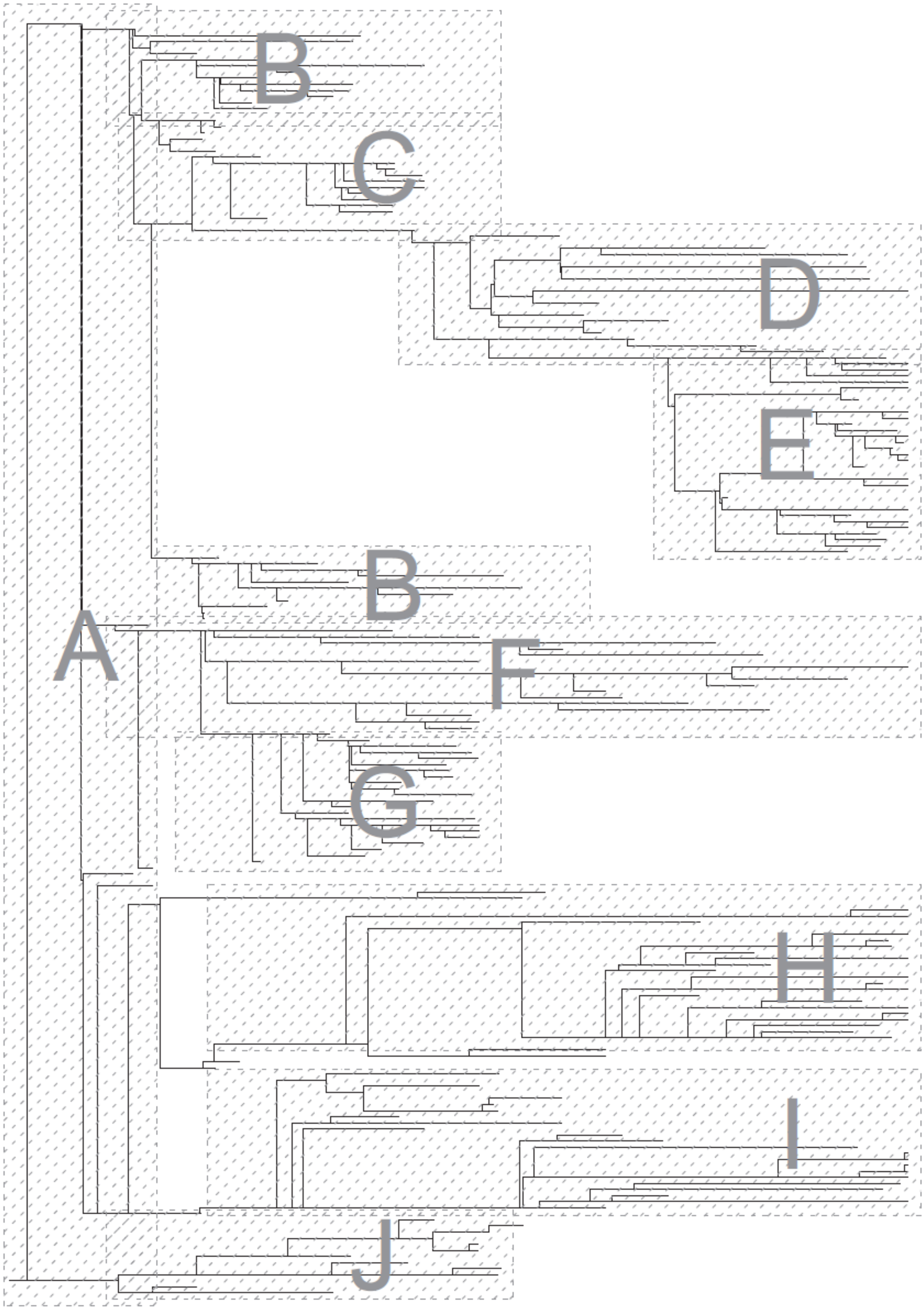


Figure 2.4 The morphospecies phylogeny as a legend; letters correspond to subsequent panels in Fig. 2.5 A-J containing legible details. These figures were drawn using paleoPhylo (Ezard & Purvis 2009) in the R environment (version 2.10.1, R Development Core Team 2010).

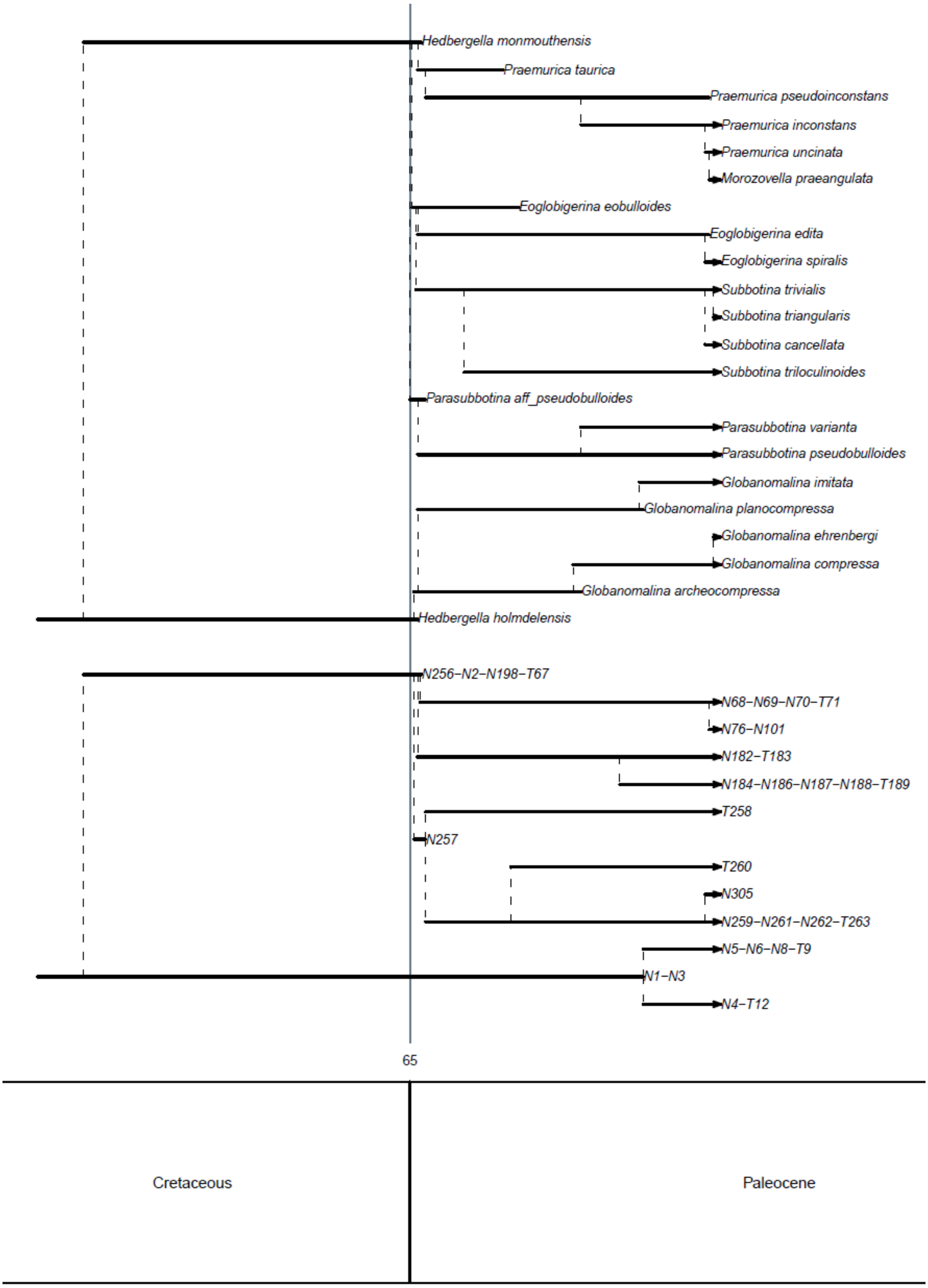


Figure 2.5.A Descendants of *Hedbergella holmdelensis* shown as both morphospecies (top) and evolutionary lineages (bottom). Further details of the morphospecies included in the evolutionary lineages detailed in Figures 2.5 A-J is available in the online supplementary information, along with the data required for constructing the both of the phylogenies presented and the according Hennigian lineage phylogeny. The timescale is from Berggren et al. (1995) and Berggren & Pearson (2005) and the figure was drawn using paleoPhylo (Ezard & Purvis 2009).

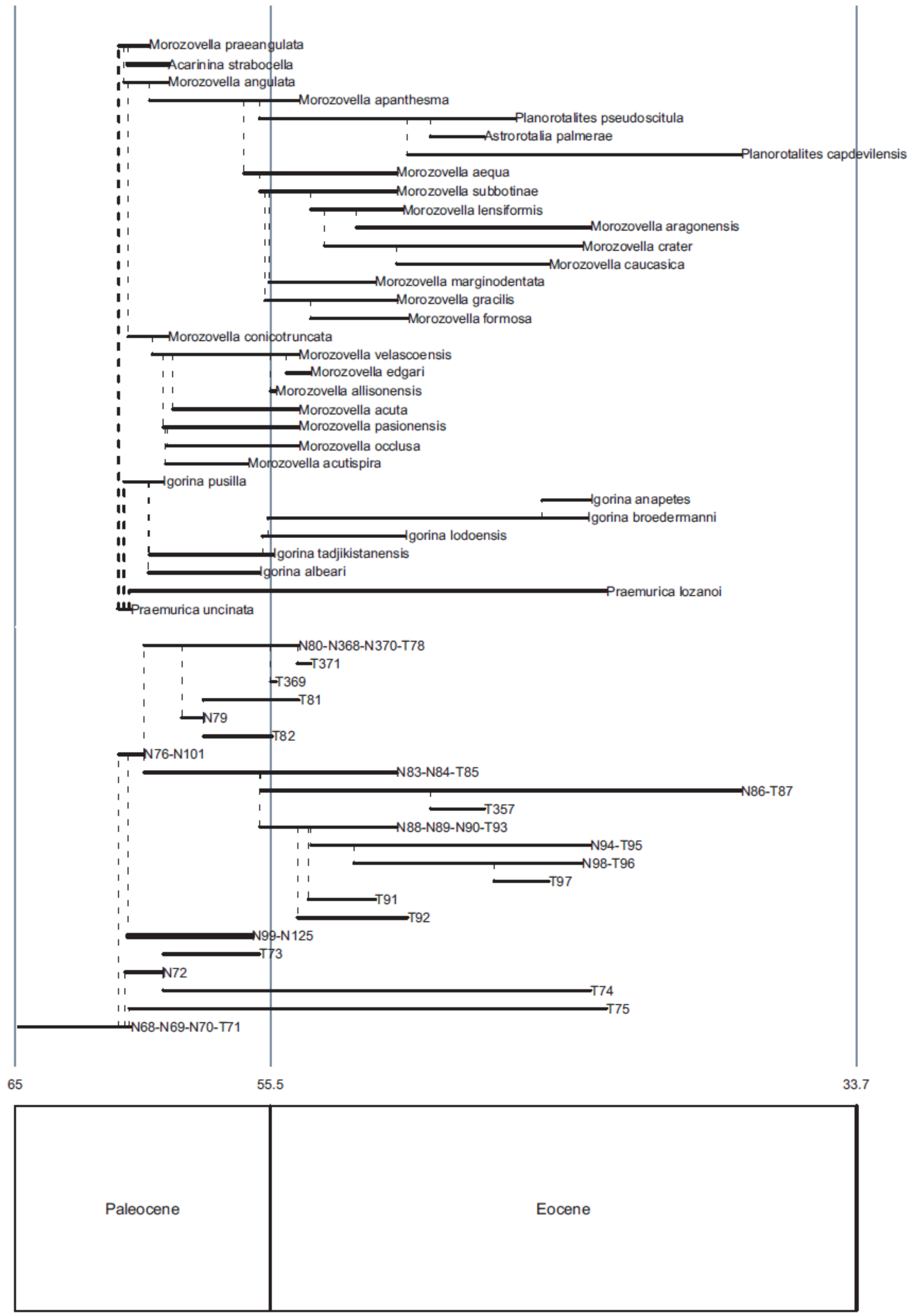


Figure 2.5.B Descendants of *Praemurica unicinata* shown as both morphospecies (top) and evolutionary lineages (bottom). *Praemurica unicinata* is descended from *Praemurica inconstans* (Fig. 2.5.A). *Acarinina strabocella* and its corresponding lineage (highlighted with bold lines) have descendants which are detailed in Fig. 2.5.C.

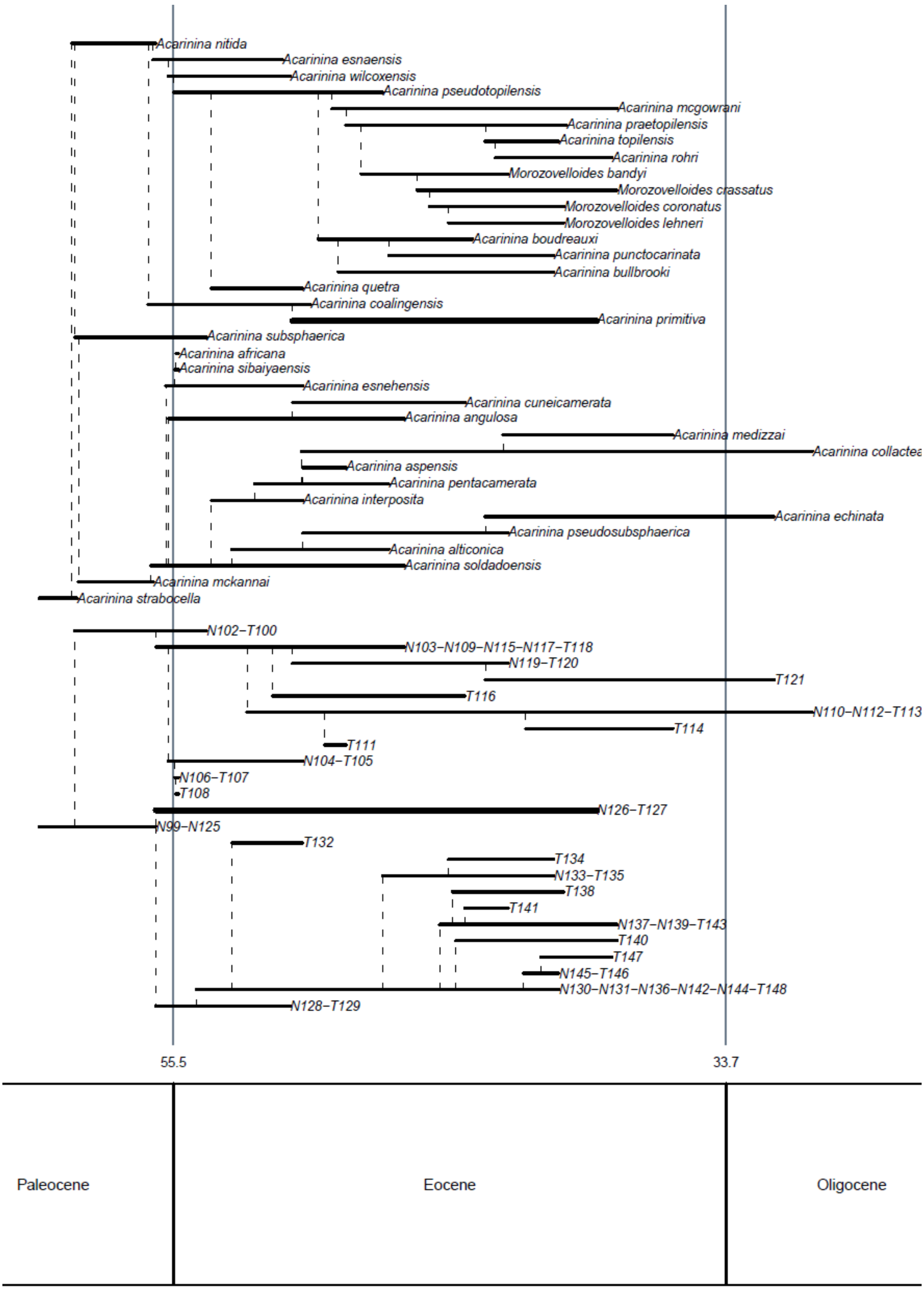


Figure 2.5.C Descendants of *Acarinina strabocella* shown as both morphospecies (top) and evolutionary lineages (bottom). *A. strabocella* is descended from *Morozovella praeangulata* (Fig. 2.5.B). *Acarinina primitiva* and its corresponding lineage (highlighted with bold lines) have descendants which are detailed in Fig. 2.5.D.

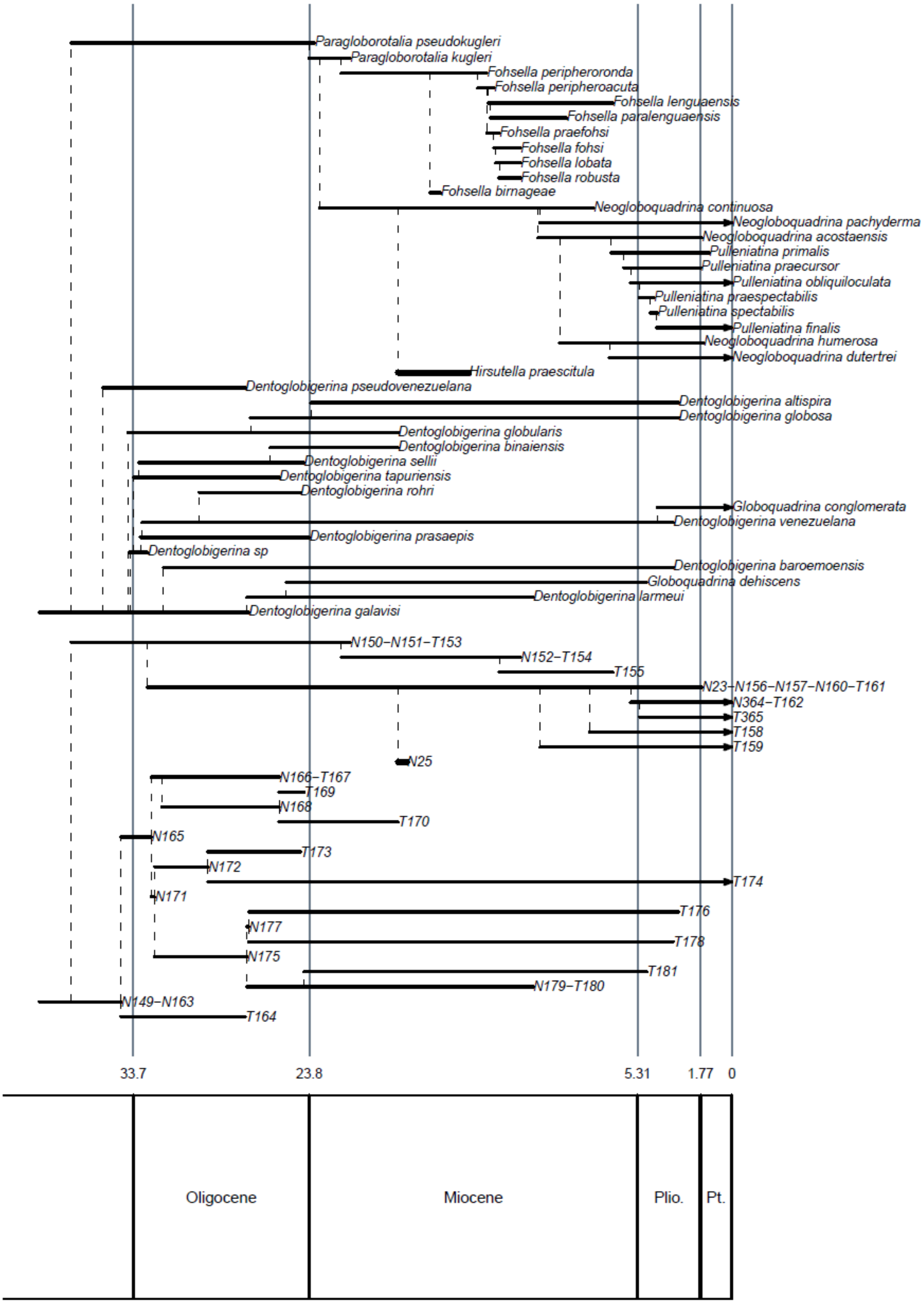


Figure 2.5.D Descendants of *Dentoglobigerina galavisi* shown as both morphospecies (top) and evolutionary lineages (bottom). *D. galavisi* is descended from *Acarinina primitiva* (Fig. 2.5.C). *Hirsutella praescitula* and its corresponding lineage (highlighted with bold lines) have descendants which are detailed in Fig. 2.5.C.

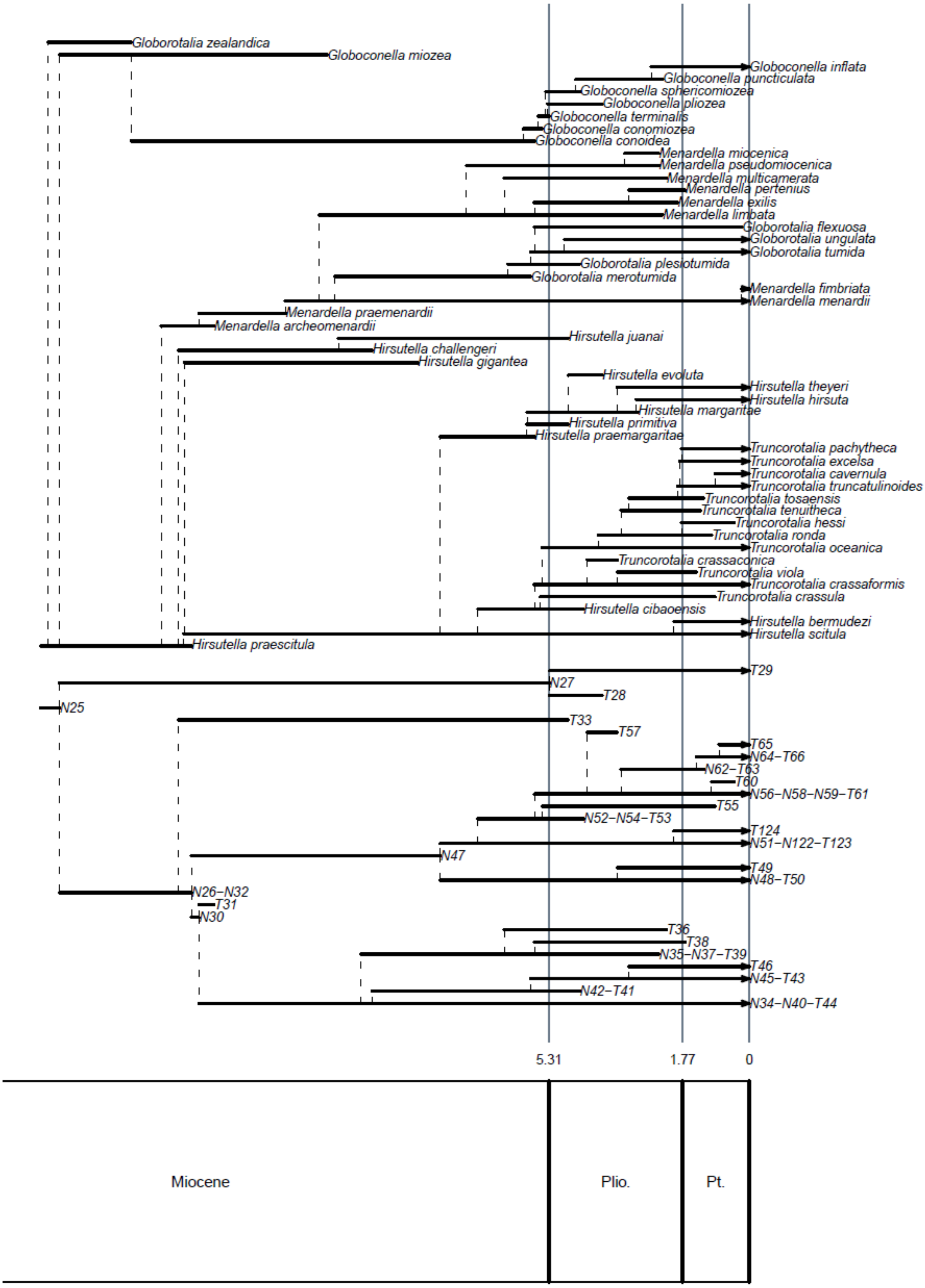


Figure 2.5.E Descendants of *Hirsutella praescitula* shown as both morphospecies (top) and evolutionary lineages (bottom). *H. praescitula* is descended from *Neogloboquadrina continuosa* (Fig. 2.5.D).

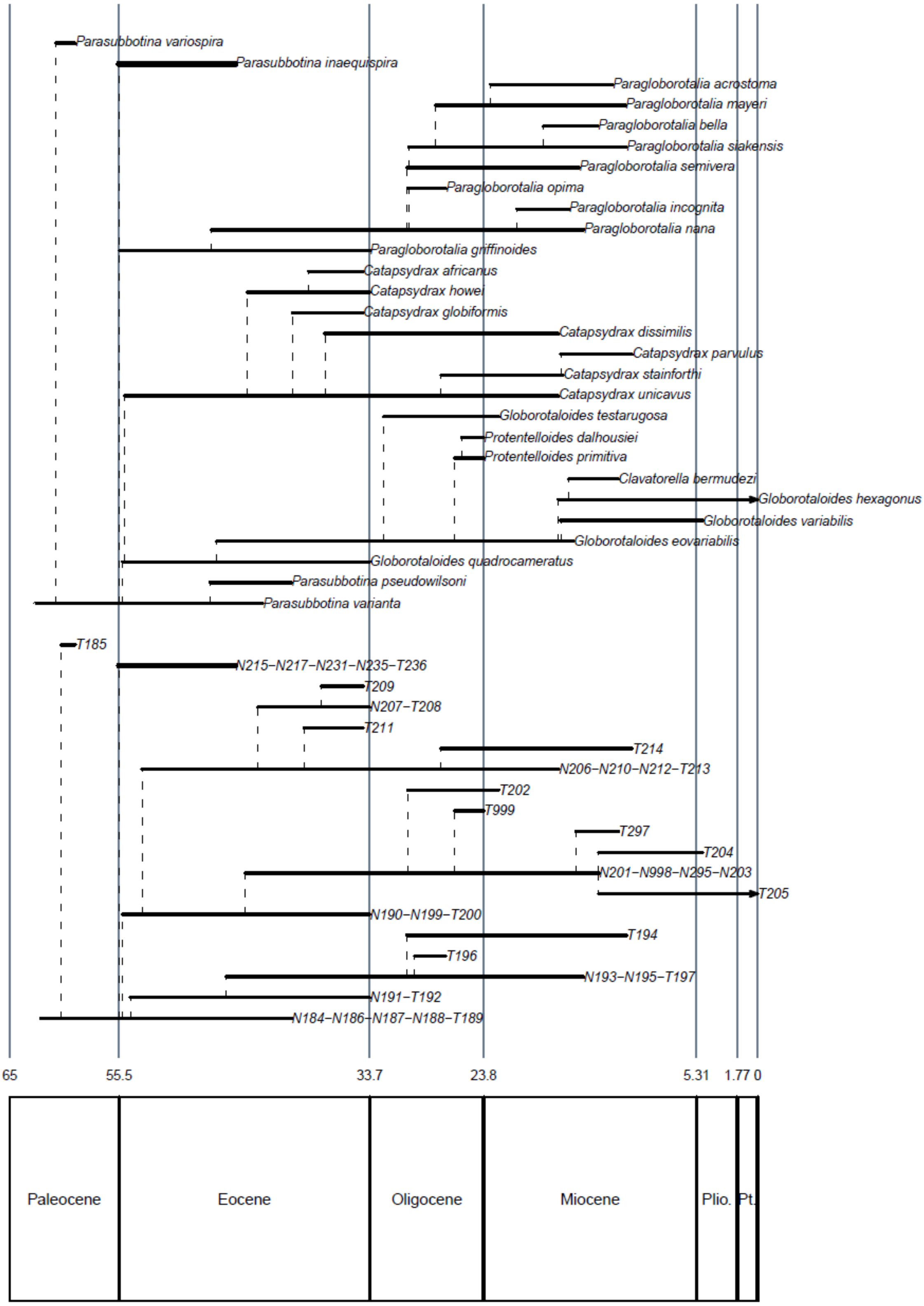


Figure 2.5.F Descendants of *Parasubbotina varianta* shown as both morphospecies (top) and evolutionary lineages (bottom). *P. varianta* is descended from *Parasubbotina pseudobulloides* (Fig. 2.5.A). *Parasubbotina inaequispira* and its corresponding lineage (highlighted with bold lines) have descendants which are detailed in Fig. 2.5.G.

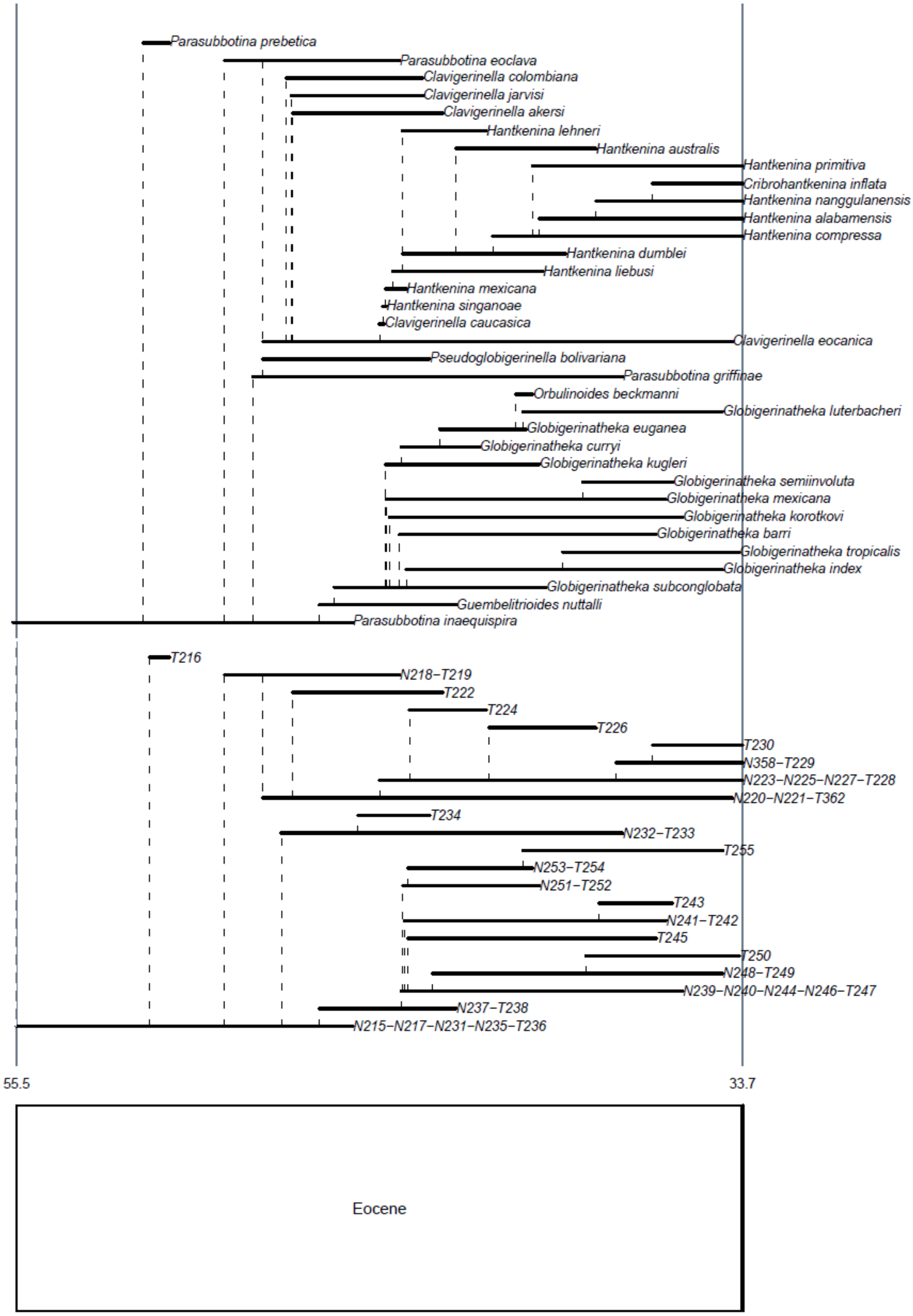


Figure 2.5.G Descendants of *Parasubbotina inaequispira* shown as both morphospecies (top) and evolutionary lineages (bottom). *P. inaequispira* is descended from *P. varianta* (Fig. 2.5.H).

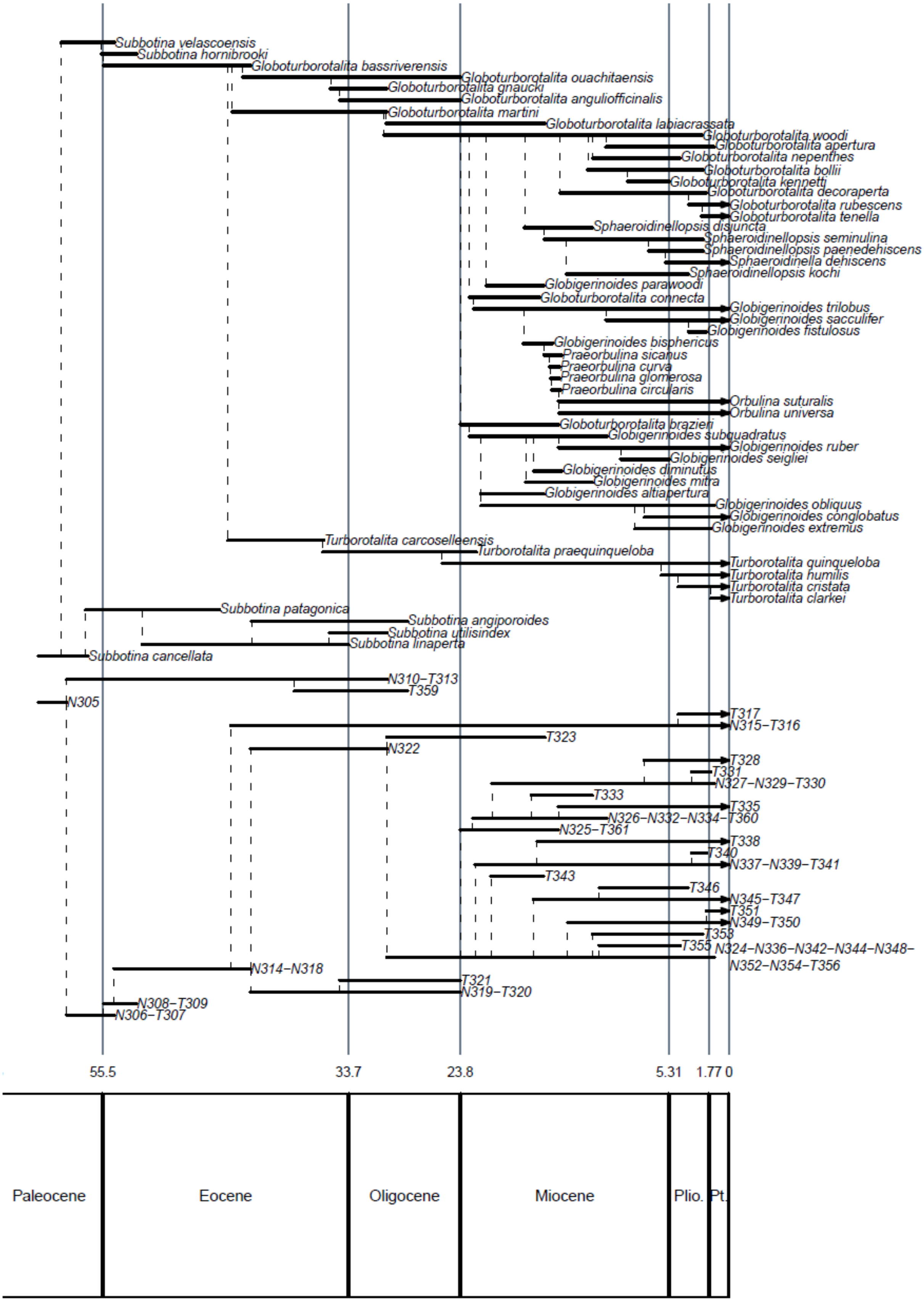


Figure 2.5.H Descendants of *Subbotina cancellata* shown as both morphospecies (top) and evolutionary lineages (bottom). *S. cancellata* is descended from *Subbotina trivialis* (Fig. 2.5.A).

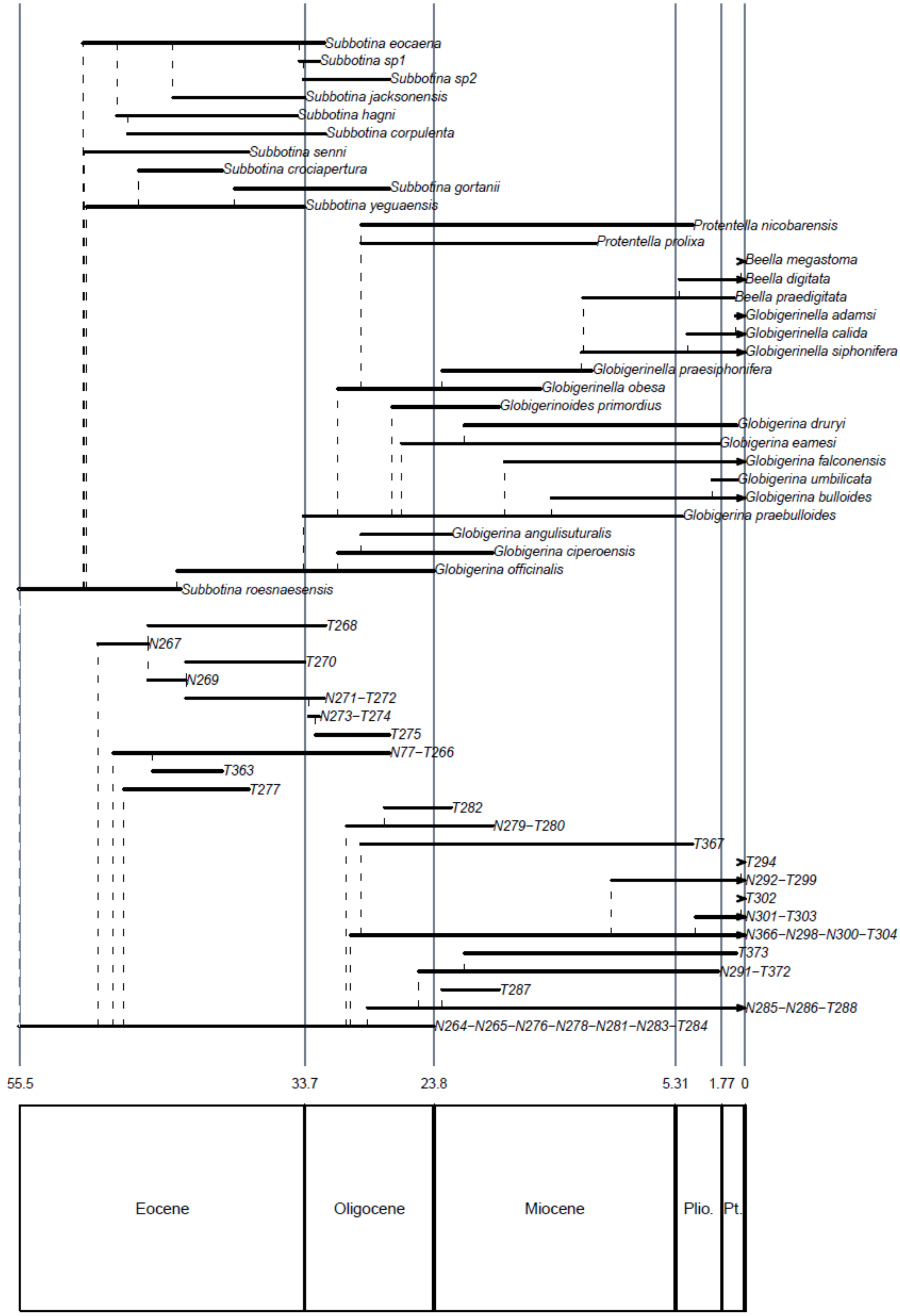


Figure 2.5.I Descendants of *Subbotina roesnaesensis* shown as both morphospecies (top) and evolutionary lineages (bottom). *S. roesnaesensis* is descended from *Subbotina triangularis* (Fig. 2.5.A).

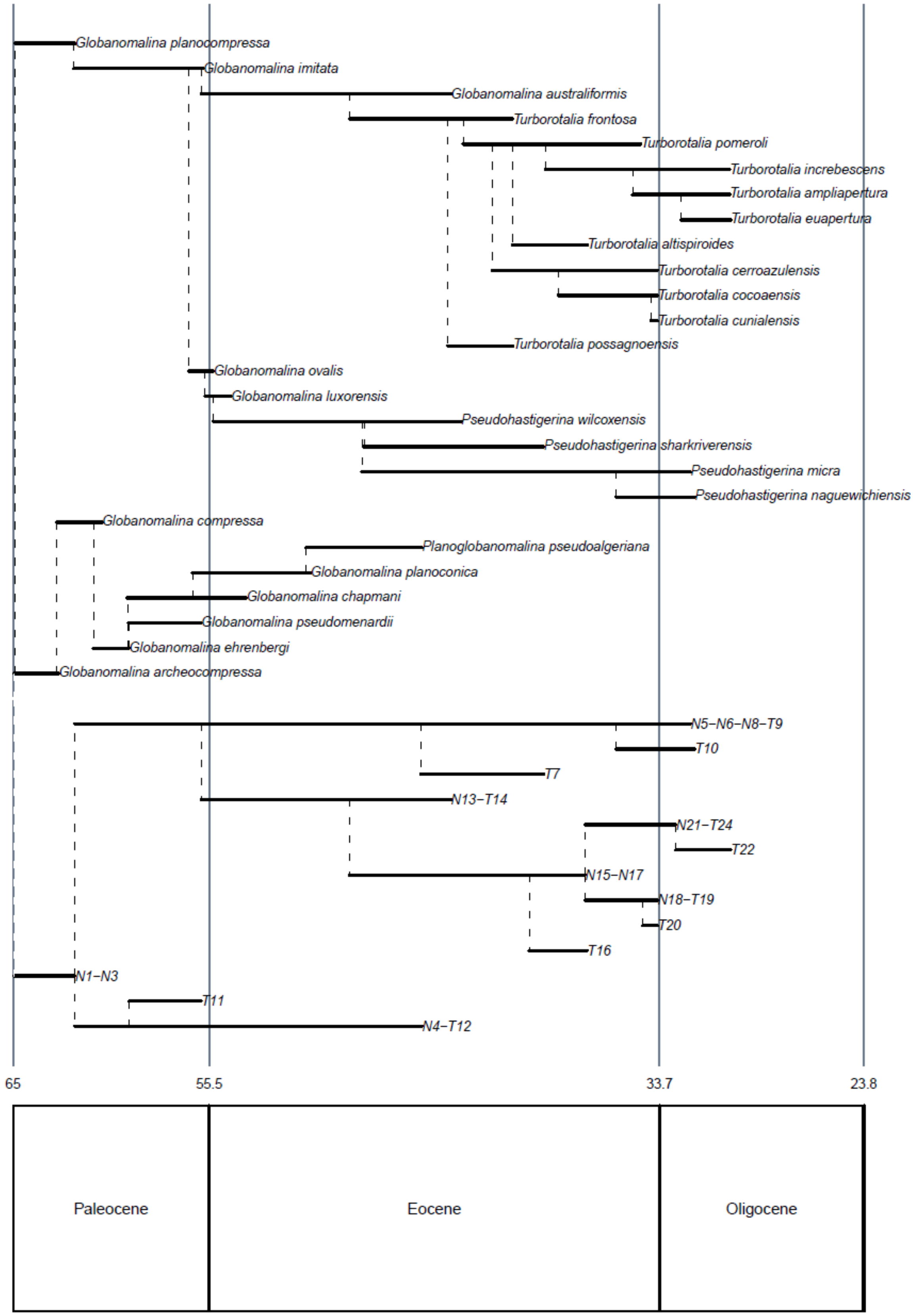


Figure 2.5.J Descendants of *Globanomalina archeocompressa* shown as both morphospecies (top) and evolutionary lineages (bottom). *G. archeocompressa* is descended from *Hedbergella holmdelensis* (Fig. 2.5.A).

Many of the evolutionary relationships depicted are necessarily tentative, awaiting better fossil resolution and more detailed morphometrics that could underpin more robust hypotheses about ancestry. Although Paleocene and Eocene relationships are generally more robust, having been reviewed in the *Atlas of Paleocene Planktonic Foraminifera* (Olsson *et al*., 1999) and the *Atlas of Eocene Planktonic Foraminifera* (Pearson *et al*., 2006), the origin of the genus *Dentoglobigerina* is still uncertain (Fig. 2.5.E). Due to the absence of spine holes it was suggested by Olsson, Hemleben and Pearson (2006) that *Dentoglobigerina* be derived from the muricate genus *Acarinina* during the Eocene, but an alternative and more traditional hypothesis would derive *Dentoglobigerina* from the subbotiniids with a subsequent loss or reduction of spines. The suggestion of a muricate ancestor has been followed but uncertainty will persist until more morphological intermediates are discovered.

'Paragloborotalia' kugleri and '*P*'. *pseudokugleri* also have uncertain ancestry dependent on the presence or absence of spines. Both were described as spinose by Spezzaferri (1994) and Rögl (1985), but more recent scanning electron microscope (SEM) observations of extremely well-preserved specimens by Pearson & Wade (2009) found no evidence of spine holes. We have therefore provisionally derived '*P*'. *kugleri* and '*P*'. *pseudokugleri* from *Dentoglobigerina* on the basis of morphological similarity (see Fig. 2.5.D).

The morphospecies phylogeny of Neogene globorotaliids was taken from Stewart (2003), which is a comprehensive revision of this large group using cladistics, stratocladistics and stratophenetics. The origin of the globorotaliids is contentious. Hilbrecht & Thierstein (1996) proposed that this clade arose from a separate benthic source based on their observations of 'benthic-like' behaviour in laboratory culture; specimens exhibit a crawling motion around the bottom of a Petri dish. Here the globorotaliids are derived from *Paragloborotalia kugleri* (Fig. 2.5.D) due to a possible relict cancellate wall texture in the globorotaliid ancestor *H. praescitula* as suggested by McGowran (1968), Kennett & Srinivasan (1983) Cifelli & Scott (1986) and Spezzaferri (1994).

The genera *Hastigerina* and *Orcadia* were removed from the phylogeny due to the unclear status of this clade. Both genera have tri-radiate, barbed spines and a wall unlike any other Cenozoic spinose forms (Holmes, 1984; personal observations of specimens from the GLOW cruise). They also have a poor fossil record (which may be due to their extremely thin and delicate test wall) which makes stratophenetic tracing of their evolutionary history through sediments very difficult.

2.3.2 Conversion to a lineage phylogeny

To completely eliminate pseudospeciation and pseudoextinction from a stratophenetic phylogeny would require detailed morphometric work across the entire phylogeny, in order to identify lineages that diverge in morphospace. Parts of the phylogeny have been the subject of such studies (e.g. Malmgren & Kennett, 1981; Wei, 1987; Stewart, 2003; Hull & Norris, 2009). More commonly, the literature contains qualitative observations that one morphospecies is seen to intergrade with another, or descriptions of last occurrences as pseudoextinctions rather than real extinctions. Even so, many qualitative decisions were made on the timing and pattern of individual branching events based on personal observations of the fossil record, discussion with colleagues, and ongoing re-sampling of the phylogeny for a study of size and shape change (T. Aze, unpublished data). 117 of the 297 extinction events (39%) seen in the morphospecies tree are assessed as pseudoextinctions. Segments of branch between adjacent nodes in Fig. 2.1 C, and between a terminal species and its parent node, correspond to what Meier & Willmann (2000) term Hennigian species.

2.3.3 Distinction between budding and bifurcating relationships within the lineage phylogeny

Cladogenetic events in the lineage phylogeny can be of two types – budding or bifurcating. At budding cladogenetic events, a new lineage arises whilst the ancestral form remains morphologically the same and persists to coexist with the new lineage. Bifurcating events occur when a lineage splits into two morphologically distinct entities, both different from the ancestral lineage that gave rise to them, which then ceases to exist (compare Fig. 2.1.A & B). Vertical lines on this phylogeny correspond to Simpson's (1951) concept of evolutionary species (Fig. 2.3.A, with detail in Fig. 2.5.A-J) which is more inclusive than the Hennigian concept because ancestors are permitted to persist through a speciation event.

2.3.4 Assignment of taxa to morphogroups and ecogroups

The morphospecies and lineages presented in the phylogenies were assigned to morphogroups based upon distinctive architectural features of the test and are separated into two major divisions – those with spines and those without (Table 2.1).

Table 2.1 Morphogroup descriptions, which split the macroperforate planktonic foraminifera into two main groups (spinose or non-spinose) but which also contain substantial variation providing subdivisions (example genera shown).

Wall type	Test architecture	Example genera
Spinose	flat	*Turborotalita*
	globular	*Subbotina, Globigerina, Globoturborotalita*
	globular with supplementary apertures	*Globigerinoides, Globigerinatheka, Guembilitriodes*
	spherical	*Praeorbulina, Orbulina, Orbulinoides, Globigerinatheka*
	clavate	*Beella*
	planispiral	*Globigerinella*
Non-spinose	globular	*Globoquadrina*
	globular, keeled	*Pulleniatina spectabilis*
	planispiral	*Pseudohastigerina*
	tubulospinate	*Hantkenina*
	keel spines	*Astrorotalia*
	turborotaliform, keeled	*Turborotalia, some Truncorotalia, Fohsella*
	turborotaliform, non-keeled	*Hedbergella*
	globorotaliform, keeled	*Menardella*
	globorotaiform, anguloconical	*some Truncorotalia*

	globorotaliform, non-keeled	*Hirsutella*
	muricate, acarininiform	*Acarinina*
	muricocarinate, keeled	some *Morozovella, Morozovelloides*
	muricocarinate, anguloconical	some *Morozovella, Morozovelloides*

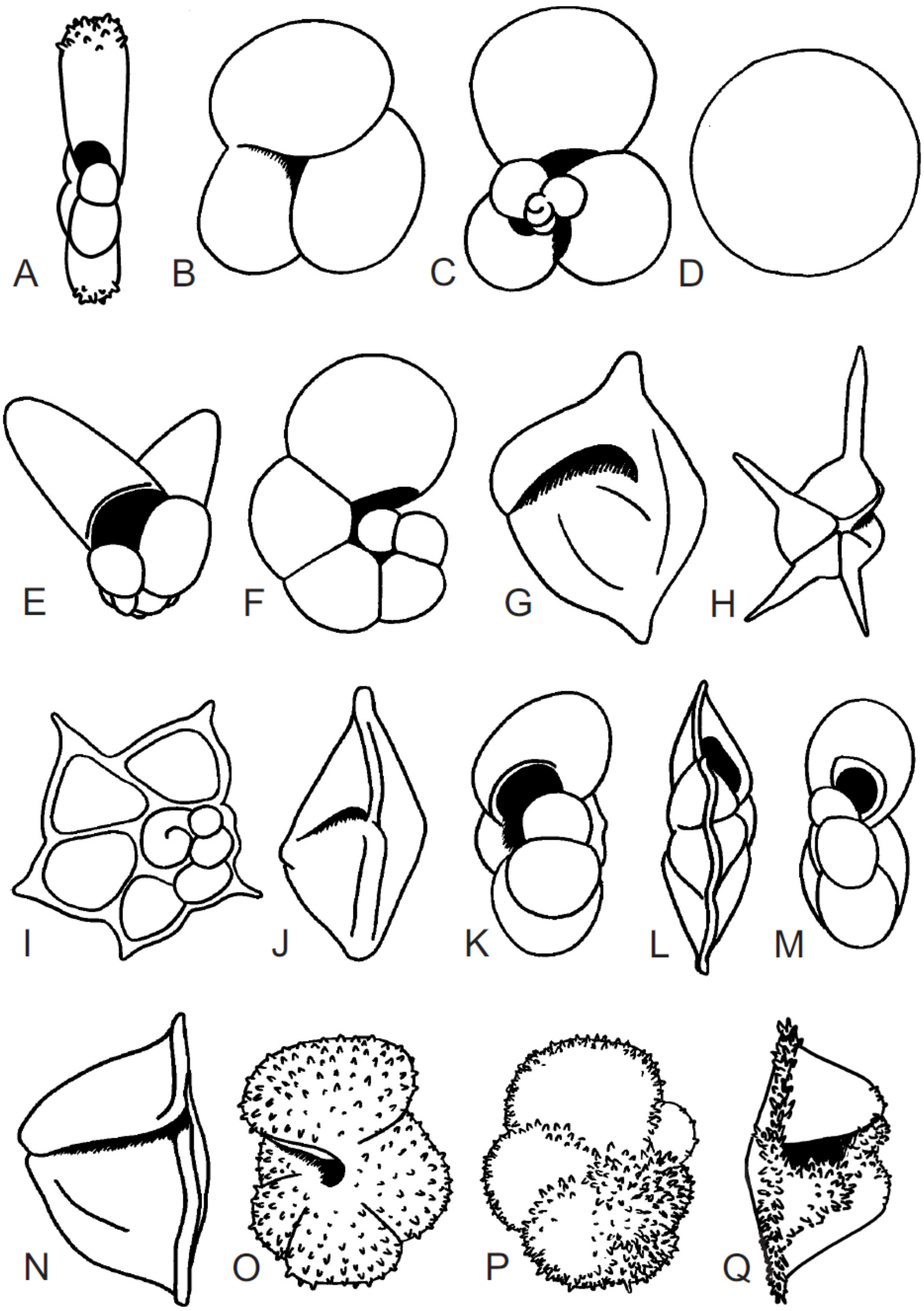


Figure 2.6 Representative illustrations of the 19 morphotypes used in this study. (A) 1. Spinose, flat. (B) 2. Spinose, globular and 7. Non-spinose, globular. (C) 3. Spinose, globular with supplementary apertures. (D) 4. Spinose, spherical. (E) 5. Spinose, clavate. (F) 6. Spinose, planispiral and 9. Non-spinose, planispiral. (G) Non-spinose, keeled. (H) Non-spinose, tubulospinate. (I) Non-spinose, keeled spines. (J) Non-spinose, turborotaliform keeled. (K) Non-spinose, turborotaliform non-keeled. (L) Non-spinose, globorotaliform keeled. (M) Non-spinose, globorotaliform non-keeled. (N) Non-spinose, globorotaliform anguloconical. (O) Non-spinose, muricocarinate acarininaform. (P) Non-spinose, muricocarinate keeled. (Q) Non-spinose, muricocarinate anguloconical. Not to scale.

Table 2.2 A table containing information and accompanying references for the morphology of all Cenozoic macroperforate planktonic foraminifer species included in the phylogenies.

Species name	General test architecture	Spinose / Non-spinose	Wall ultra-structure	Aperture type	Morpho-group	Morpho-group reference
Acarinina africana	Umbilico-convex to weakly biconvex, low trochospiral	Non-spinose	Muricate	Umbilical-extraumbilical low arch sometimes with faint lip	17	Berggren et al. (2006b)
Acarinina alticonica	Biconvex to subspherical, moderate to high trochospiral	Non-spinose	Muricate	Umbilical-extraumbilical low arch bordered by distinct lip	17	Berggren et al. (2006b)
Acarinina angulosa	Umbilico-convex, trochospiral	Non-spinose	Muricate	Interiomarginal umbilical low arch extending nearly to periphery	17	Berggren et al. (2006b)
Acarinina aspensis	Umbilico-convex, low trochospiral	Non-spinose	Muricate	Interiomarginal umbilical-extraumbilical opening extending to peripheral margin	17	Berggren et al. (2006b)
Acarinina boudreauxi	Planoconvex umbilico-convex, low trochospiral	Non-spinose	Muricate	Umbilical-extraumbilical low arch	17	Berggren et al. (2006b)
Acarinina bullbrooki	Umbilico-convex, low trochospiral, quadrate	Non-spinose	Muricate	Umbilical-extraumbilical low rimmed opening extending toward but not reaching periphery	17	Berggren et al. (2006b)
Acarinina coalingensis	Trochospiral, globular	Non-spinose	Muricate	Interiomarginal umbilical-extraumbilical small slit	17	Olsson et al. (1999)
Acarinina collactea	Biconvex, low trochospiral	Non-spinose	Muricate	Low-arched slit along base of last chamber	17	Berggren et al. (2006b)
Acarinina cuneicamerata	Umbilico-convex, low trochospiral	Non-spinose	Muricate	Umbilical-extraumbilical extending almost to periphery bordered by distinct circumumbilical lip	17	Berggren et al. (2006b)

Species name	**General test architecture**	**Spinose / Non-spinose**	**Wall ultra-structure**	**Aperture type**	**Morpho-group**	**Morpho-group reference**
Acarinina echinata	Biconvex, low trochospiral	Non-spinose	Muricate	Umbilical-extraumbilical low arch with narrow lip and two-three low-arched supplementary apertures along umbilical sutures	17	Berggren et al. (2006b)
Acarinina esnaensis	Umbilico-convex, low trochospiral	Non-spinose	Muricate	Interiomarginal umbilical-extraumbilical long low arch extending nearly to the periphery with very thin lip	17	Berggren et al. (2006b)
Acarinina esnehensis	Umbilico-convex, low to moderately high spired trochospiral, subquadrate outline	Non-spinose	Muricate	Interiomarginal umbilical-extraumbilical long low arch extending with thin lip extending nearly to periphery	17	Berggren et al. (2006b)
Acarinina interposita	Umbilico-convex, low trochospiral	Non-spinose	Muricate	Umbilical-extraumbilical arch with thin lip extending almost to periphery	17	Berggren et al. (2006b)
Acarinina mcgowrani	Moderate trochospiral	Non-spinose	Muricate	Umbilical-extraumbilical opening supplementary apertures frequently occur commonly with bullae	17	Berggren et al. (2006b)
Acarinina mckannai	Umbilico-convex, trochospiral	Non-spinose	Muricate	Interiomarginal umbilical-extraumbilical elongate opening	17	Olsson et al. (1999)
Acarinina medizzai	Biconvex trochospiral, quadrate to subcircular outline	Non-spinose	Muricate	Umbilical-extraumbilical small indistinct low arch	17	Berggren et al. (2006b)
Acarinina nitida	Umbilico-convex, trochospiral	Non-spinose	Muricate	Interiomarginal umbilical-extraumbilical narrow opening with slight lip	17	Olsson et al. (1999)
Acarinina pentacamerata	Weakly biconvex, low trochospiral	Non-spinose	Muricate	Umbilical-extraumbilical low slit	17	Berggren et al. (2006b)
Acarinina praetopilensis	Umbilico-convex, low trochospiral	Non-spinose	Muricate	Umbilical-extraumbilical opening with weak rim	17	Berggren et al. (2006b)

Species name	**General test architecture**	**Spinose / Non-spinose**	**Wall ultra-structure**	**Aperture type**	**Morpho-group**	**Morpho-group reference**
Acarinina primitiva	Sub-quadrate, trochospiral	Non-spinose	Muricate	Interiomarginal umbilical-extraumbilical asymmetrically placed	17	Berggren et al. (2006b)
Acarinina pseudosubsphaerica	Spiroconvex, high trochospiral	Non-spinose	Muricate	Umbilical slit or low broad arch	17	Berggren et al. (2006b)
Acarinina pseudotopilensis	Umbilico-convex to weakly biconvex, low trochospiral	Non-spinose	Muricate	Umbilical-extraumbilical low arch bordered by narrow continuous lip	17	Berggren et al. (2006b)
Acarinina punctocarinata	Umbilico-convex, low trochospiral	Non-spinose	Muricate	Umbilical-extraumbilical low arch bordered by distinct lip	17	Berggren et al. (2006b)
Acarinina quetra	Umbilico-convex, low trochospiral	Non-spinose	Muricate	Umbilical-extraumbilical low extending towards (but not reaching) periphery	17	Berggren et al. (2006b)
Acarinina rohri	Umbilico-convex, low trochospiral	Non-spinose	Muricate	Umbilical-extraumbilical low extending towards peripheral margin	17	Berggren et al. (2006b)
Acarinina sibaiyaensis	Umbilico-convex, trochospiral almost planispiral	Non-spinose	Muricate	Umbilical-extraumbilical circular arch with lip to well-developed flange	17	Berggren et al. (2006b)
Acarinina soldadoensis	Umbilico-convex, low trochospiral	Non-spinose	Muricate	Large arcuate apertures of last-formed chambers with thin bordering lips	17	Olsson et al. (1999)
Acarinina strabocella	Biconvex, trochospiral	Non-spinose	Muricate	Interiomarginal umbilical-extraumbilical slit with lip	17	Olsson et al. (1999)
Acarinina subsphaerica	Spiroconvex, trochospiral	Non-spinose	Muricate	Interiomarginal umbilical-extraumbilical semicircular arch	17	Olsson et al. (1999)
Acarinina topilensis	Umbilico-convex, trochospiral	Non-spinose	Muricate	Umbilical-extraumbilical arch with thin lip	17	Berggren et al. (2006b)
Acarinina wilcoxensis	Umbilico-convex, trochospiral	Non-spinose	Muricate	Umbilical-extraumbilical arch with thin lip	17	Berggren et al. (2006b)

Species name	General test architecture	Spinose / Non-spinose	Wall ultra-structure	Aperture type	Morpho-group	Morpho-group reference
Astrorotalia palmerae	Low trochospiral, keeled periphery with spines	Non-spinose	Weakly muricate	Umbilical-extraumbilical low slit bordered by thick lip extending to periphery	11	Berggren et al. (2006a)
Beella digitata	Medium to high trochospiral, chambers digitate	Spinose	Irregularly cancellate	Interiomarginal umbilical-extraumbilical wide open arch bordered by a thick lip	5	Kennett & Srinivasan (1983)
Beella megastoma	Trochospiral becoming streptospiral, chambers rounded to digitate	Spinose	Irregularly cancellate	Interiomarginal umbilical-extraumbilical wide open symmetrical arch bordered by a thin lip	5	Holmes (1984)
Beella praedigitata	Low to medium trochospiral, lobulate periphery	Spinose	Smooth	Interiomarginal umbilical semicircular arch bordered by a pronounced lip	5	Kennett & Srinivasan (1983)
Catapsydrax africanus	Globular, low trochospiral with umbilical bulla	Spinose	Cancellate	Three-four infralaminial apertures with continous thickened imperforate rims	2	Olsson et al. (2006c)
Catapsydrax dissimilis	Globular, low trochospiral with umbilical bulla	Spinose	Cancellate	One or more infralaminial apertures with thickened imperforate rims	2	Kennett & Srinivasan (1983)
Catapsydrax globiformis	Nearly spherical, low trochosprial with umbilical bulla	Spinose	Cancellate	Three-four infralaminial apertures with continous thickened imperforate rims	4	Olsson et al. (2006c)
Catapsydrax howei	Globular, low trochospiral with umbilical bulla	Spinose	Cancellate	Three large circular infralaminial apertures with continous thickened imperforate rims	2	Olsson et al. (2006c)
Catapsydrax parvulus	Sub-globular, low trochospiral with umbilical bulla	Spinose	Cancellate	Interiomarginal umbilical covered by an arched bulla with a single infralaminal aperture on one side	2	Kennett & Srinivasan (1983)

Species name	General test architecture	Spinose / Non-spinose	Wall ultra-structure	Aperture type	Morpho-group	Morpho-group reference
Catapsydrax stainforthi	Sub-quadrate, low trochospiral	Spinose	Cancellate	Interiomarginal umbilical covered by a bulla with an infralaminal aperture over each suture of the final whorl	2	Kennett & Srinivasan (1983)
Catapsydrax unicavus	Low trochospiral, lobulate	Spinose	Cancellate	Infralaminal associated with the bulla has a continuous thickened imperforate rim	2	Olsson et al. (2006c)
Clavatorella bermudezi	Low trochospiral, lobulate later chambers club-shaped	Spinose	Coarsely cancellate	Umbilical-extraumbilical interiormarginal elongate arch bordered by a distinct lip	5	Kennett & Srinivasan (1983)
Clavigerinella akersi	Planispiral or pseudo-planispiral, evolute biumbilicate	Probably spinose	Weakly cancellate or smooth	Equatorial symmetrical high arch with a smooth broad imperforate lip	6	Coxall & Pearson (2006)
Clavigerinella caucasica	Planispiral or pseudo-planispiral, evolute biumbilicate	Probably spinose	Weakly cancellate or smooth	Equatorial symmetrical distinctly pointed high arch with smooth broad imperforate lips	6	Coxall & Pearson (2006)
Clavigerinella colombiana	Planispiral involute, biumbilicate	Probably spinose	Weakly cancellate or smooth	Equatorial symmetrical narrow arch with a smooth imperforate lip	6	Coxall & Pearson (2006)
Clavigerinella eocanica	Planispiral or pseudo-planispiral, evolute biumbilicate	Probably spinose	Weakly cancellate or smooth	Equatorial symmetrical high arch with a smooth broad imperforate lip	6	Coxall & Pearson (2006)
Clavigerinella jarvisi	Planispiral or pseudo-planispiral, evolute biumbilicate, chambers digitate	Probably spinose	Weakly cancellate or smooth	Equatorial symmetrical high arch with a smooth broad imperforate lip	6	Coxall & Pearson (2006)
Cribrohantkenina inflata	Planispiral biumilicate, chambers tubulospinose	Probably non-spinose	Smooth	Equatorial symmetrical low or high and narrow arch with an imperforate lip and one or more areal apertures on the final chamber	10	Coxall & Pearson (2006)

Species name	General test architecture	Spinose / Non-spinose	Wall ultra-structure	Aperture type	Morpho-group	Morpho-group reference
Dentoglobigerina altispira	High trochospiral	Non-spinose	Cancellate	Umbilically restricted with umbilical teeth projecting into umbilicus	7	Kennett & Srinivasan (1983)
Dentoglobigerina baroemoensis	Low trochospiral, subquadrate periphery	Non-spinose	Cancellate	Interiomarginal umbilical covered with a distinct narrow protruding umbilical tooth	7	Kennett & Srinivasan (1983)
Dentoglobigerina binaiensis	Spiro-convex, low trochospiral, subquadrate	Non-spinose	Cancellate	Interiomarginal umbilical low arch with a very weak umbilical tooth	7	Kennett & Srinivasan (1983)
Dentoglobigerina galavisi	Trochospiral, globular oval in outline	Non-spinose	Cancellate	Umbilical bordered by thin irregular triangular-shaped lip	7	Olsson et al. (2006b)
Dentoglobigerina globosa	Trochospiral, periphery lobulate	Non-spinose	Cancellate	Interiomarginal umbilical covered by tooth-like projections	7	Kennett & Srinivasan (1983)
Dentoglobigerina globularis	Low trochospiral, profile subovate with lobate periphral margin, rounded	Non-spinose	Cancellate	Umbilical high arch displaying a triangular tooth	7	Spezzaferri (1994)
Dentoglobigerina larmeui	Low trochospiral, compact, profile subtriangular, slightly lobulate	Non-spinose	Cancellate	Umbilical-extraumbilical low arch with a thick well-developed large asymmetrical tooth	7	Spezzaferri (1994)
Dentoglobigerina prasaepis	Large, low trochospiral, profile circular, slightly lobate	Non-spinose	Cancellate	Umbilical middle deep high arch embracing the three previous chambers	7	Spezzaferri (1994)
Dentoglobigerina pseudovenezuelana	Globular, trochospiral, subcircular to subquadrate in outline	Non-spinose	Cancellate	Umbilical bordered by thin irregular subtriangular-shaped lip	7	Olsson et al. (2006b)
Dentoglobigerina rohri	Large, low trochospiral and streptospiral, profile circular and slightly lobate	Non-spinose	Cancellate	Umbilical low asymmetrical arch	7	Spezzaferri (1994)
Dentoglobigerina sellii	Low trochospiral, compact, profile subcircular to subrectangular, slightly lobate	Non-spinose	Cancellate	Elongate narrow slit with thin but distinct tooth-like lip	7	Spezzaferri (1994)

Species name	**General test architecture**	**Spinose / Non-spinose**	**Wall ultra-structure**	**Aperture type**	**Morpho-group**	**Morpho-group reference**
Dentoglobigerina sp		Non-spinose	Cancellate		7	B. S. Wade & P. N. Pearson personal communication
Dentoglobigerina tapuriensis	Low trochospiral, profile subrectangular and slightly lobate	Non-spinose	Cancellate	Slighlty arched slit	7	Spezzaferri (1994)
Dentoglobigerina venezuelana	Low trochospiral, equatorial periphery slightly lobate	Non-spinose	Cancellate	Interiomarginal umbilical low arch with umbilical teeth	7	Kennett & Srinivasan (1983)
Eoglobigerina edita	Umbilico-convex, moderately elevated trochospiral	Spinose	Cancellate (weakly developed)	Umbilical-extraumbilical rounded arch bordered by narrow lip	2	Olsson et al. (1999)
Eoglobigerina eobulloides	Biconvex, trochospiral	Spinose	Cancellate (weakly developed)	Umbilical to slightly extraumbilical rounded arch bordered by narrow slightly flaring lip	2	Olsson et al. (1999)
Eoglobigerina spiralis	Biconvex, medium to high trochospiral	Spinose	Cancellate	Interiomarginal umbilical arch boardered by thin discontinuous lips	2	Olsson et al. (1999)
Fohsella birnageae	Biconvex, low trochospiral, equatorial profile circular	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical slit with prominent lip	13	Kennett & Srinivasan (1983)
Fohsella fohsi	Biconvex, low trochospiral, equatorial periphery lobulate with distinct keel	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low arch with prominent lip	12	Kennett & Srinivasan (1983)
Fohsella lenguaensis	Biconvex, low trochospiral, equatorial periphery almost circular but slightly lobulate	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low slit with prominent wide lip	13	Kennett & Srinivasan (1983)
Fohsella lobata	Biconvex, low trochospiral, last few chambers distinctly lobulate with keel	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical slit with small flange-like lip	12	Kennett & Srinivasan (1983)

Species name	General test architecture	Spinose / Non-spinose	Wall ultra-structure	Aperture type	Morpho-group	Morpho-group reference
Fohsella paralenguaensis	Biconvex, low trochospiral, equatorial profile ovate	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low arch with lip	13	Kennett & Srinivasan (1983)
Fohsella peripheroacuta	Biconvex, low trochospiral, equatorial periphery slightly lobulate	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low arch with prominent lip	13	Kennett & Srinivasan (1983)
Fohsella peripheroronda	Umilico-convex, very low trochospiral, equatorial periphery slightly lobulate	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low arch bordered by distinct lip	13	Kennett & Srinivasan (1983)
Fohsella praefohsi	Biconvex, low trochospiral, equatorial periphery lobulate with partly developed keel	Non-spinose	Smooth	Umbilical-extraumbilical low arch with prominent lip	12	Kennett & Srinivasan (1983)
Fohsella robusta	Biconvex, trochospiral, equatorial periphery almost circular with thick keel	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical slit with an indistinct lip	12	Kennett & Srinivasan (1983)
Globanomalina archeocompressa	Umbilico-convex, very low trochospiral	Non-spinose	Smooth	Umbilical-extraumbilical broad very low arch with continuous thin lip	13	Olsson et al. (1999)
Globanomalina australiformis	Biconvex to umbilico-convex, low trochospiral	Non-spinose	Smooth	Umbilical-extraumbilical low arch with thin lip	13	Olsson et al. (1999)
Globanomalina chapmani	Biconvex, trochospiral	Non-spinose	Smooth	Umbilical-extraumbilical elongate high arch with lip	13	Olsson et al. (1999)
Globanomalina compressa	Biconvex, trochospiral, angular periphery	Non-spinose	Smooth	Umbilical-extraumbilical low arch bordered entirely by narrow well defined lip	13	Olsson et al. (1999)
Globanomalina ehrenbergi	Low trochospire, faintly keeled	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low arch with lip	13	Olsson et al. (1999)
Globanomalina imitata	Umbilico-convex, very low trochospiral	Non-spinose	Smooth	Umbilical-extraumbilical high arch bordered by thin continuous lips	13	Olsson et al. (1999)

Species name	**General test architecture**	**Spinose / Non-spinose**	**Wall ultra-structure**	**Aperture type**	**Morpho-group**	**Morpho-group reference**
Globanomalina luxorensis	Biconvex, very low trochospiral	Non-spinose	Smooth	Umbilical-extraumbilical high arch with thin lip	13	Olsson & Hemleben (2006)
Globanomalina ovalis	Biconvex, trochospiral	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical high arch with continuous thin lip	13	Olsson et al. (1999)
Globanomalina planocompressa	Umbilico-convex, low trochospiral	Non-spinose	Smooth	Umbilical-extraumbilical rounded arch with continuous lip	13	Olsson et al. (1999)
Globanomalina planoconica	Umbilico-convex, low trochospiral	Non-spinose	Smooth	Umbilical-extraumbilical high arch with thin continuous lip	13	Olsson et al. (1999)
Globanomalina pseudomenardii	Spiroconvex to biconvex trochospiral, keeled periphery	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low arch with lip	12	Olsson et al. (1999)
Globigerina angulisuturalis	Low trochospiral, deep angular U-shaped sutures on umbilical side	Spinose	Hispid	Interiomarginal umbilical low arch	2	Kennett & Srinivasan (1983)
Globigerina bulloides	Low trochospiral, chambers spherical to subspherical	Spinose	Hispid	Umbilical high symmetrical arch	2	Kennett & Srinivasan (1983)
Globigerina ciperoensis	Low to medium trochospiral, chambers spherical	Spinose	Hispid	Umbilical circular opening	2	Kennett & Srinivasan (1983)
Globigerina druryi	Trochospiral, compact, sub-globular chambers	Spinose	Hispid	Umbilical small low arch bordered by a distinct rim	2	Kennett & Srinivasan (1983)
Globigerina eamesi	High trochospiral, subglobular chambers	Spinose	Hispid	Umbilical elongate slit with thin lip	2	Kennett & Srinivasan (1983)
Globigerina falconensis	Low trochospiral, slightly compressed, spherical chambers	Spinose	Hispid	Interiomarginal umbilical elongate narrow arch	2	Kennett & Srinivasan (1983)
Globigerina officinalis	Low trochospiral, lobulate outline	Spinose	Hispid	Umbilical low to high arch bordered by imperforate rim	2	Olsson et al. (2006a)
Globigerina praebulloides	Trochospiral, equatorial periphery elongate	Spinose	Hispid	Umbilical low to moderate asymmetrical arch	2	Kennett & Srinivasan (1983)

Species name	**General test architecture**	**Spinose / Non-spinose**	**Wall ultra-structure**	**Aperture type**	**Morpho-group**	**Morpho-group reference**
Globigerina umbilicata	Low trochospiral, chambers spherical to subspherical	Spinose	Hispid	Umbilical large opening with a thin lip	2	Kennett & Srinivasan (1983)
Globigerinatheka barri	Low to medium trochospiral, streptosprial in last whorl, subglobular to globular	Spinose	Cancellate	Primary aperture not visible three small semicircular secondary apertures present mainly covered by a small bulla	3	Premoli Silva et al. (2006)
Globigerinatheka curryi	Low to medium trochospiral, streptosprial in last whorl, subglobular	Spinose	Cancellate	Umbilical low arch with two secondary apertures at the base of the last chamber	3	Premoli Silva et al. (2006)
Globigerinatheka euganea	Low trochospiral becoming streptospiral, with final chamber hemispherical, almost spherical	Spinose	Cancellate	Primary aperture not visible two-four small semicircular secondary apertures at the base of the last chamber	4	Premoli Silva et al. (2006)
Globigerinatheka index	Low trochospiral, subrectangular	Spinose	Cancellate	Umbilical high large symmetrical arch bordered by a thick lip	3	Premoli Silva et al. (2006)
Globigerinatheka korotkovi	High trochospiral, sac like	Spinose	Cancellate	Subcircular arch with one secondary aperture almost identical to the primary aperture with other secondary apertures on spiral side	3	Premoli Silva et al. (2006)
Globigerinatheka kugleri	Subtriangular outline, rather lobate	Spinose	Cancellate	Umbilical low arch two-three secondary apertures at the base of the last chamber	3	Premoli Silva et al. (2006)
Globigerinatheka luterbacheri	Low trochospriral to streptospiral, globular	Spinose	Cancellate	Numerous secondary apertures frequently covered by a bulla of variable size	3	Premoli Silva et al. (2006)

Species name	General test architecture	Spinose / Non-spinose	Wall ultra-structure	Aperture type	Morpho-group	Morpho-group reference
Globigerinatheka mexicana	Very low trochospiral, last chamber hemispherical, almost spherical	Spinose	Cancellate	Three small to medium size arch-shaped apertures at the base of the final chamber	3	Premoli Silva et al. (2006)
Globigerinatheka semiinvoluta	Spherical, with a large hemispherical final chamber	Spinose	Cancellate	Three small to medium size arch-shaped apertures at the base of the final chamber with a rim	3	Premoli Silva et al. (2006)
Globigerinatheka subconglobata	Globular to nearly spherical, low trochospiral to streptospiral	Spinose	Cancellate	Umbilical low wide arch with one-two low-arched secondary apertures	3	Premoli Silva et al. (2006)
Globigerinatheka tropicalis	Globose with subrectangular to subtriangular outline, low trochospiral becoming streptospiral	Spinose	Cancellate	Umbilical high to subcircular medium-sized arch may have lip and is covered by a bulla secondary apertures present	3	Premoli Silva et al. (2006)
Globigerinella adamsi	Planispiral, final chambers distinctly clavate	Spinose	Hispid	Equatorial arch	5	Coxall et al. (2007)
Globigerinella calida	Low trochospiral, equatorial periphery strongly lobulate	Spinose	Hispid	Umbilical-extraumbilical with a narrow lip	2	Kennett & Srinivasan (1983)
Globigerinella obesa	Low trochospiral, strongly lobulate periphery, spherical chambers	Spinose	Hispid	Interiomarginal umbilical-extraumbilical low to medium arch	2	Kennett & Srinivasan (1983)
Globigerinella praesiphonifera	Initially trochospiral becoming planispiral in final whorl	Spinose	Hispid	Interiomarginal umbilical-extraumbilical opening	2	Kennett & Srinivasan (1983)
Globigerinella siphonifera	Initially trochospiral becoming planispiral, evolute	Spinose	Hispid	Interiomarginal wide equatorial arch without rim or lip	6	Kennett & Srinivasan (1983)
Globigerinoides altiapertura	Low trochospiral	Spinose	Cancellate	Primary aperture interiomarginal umbilical high distinct arch. One supplementary sutural aperture opposite the primary aperture	3	Kennett & Srinivasan (1983)

Species name	General test architecture	Spinose / Non-spinose	Wall ultra-structure	Aperture type	Morpho-group	Morpho-group reference
Globigerinoides bisphericus	Bilobate outline, has enveloping last chamber which almost completely hides the umbilicus	Spinose	Cancellate	Only two apertures are present along the suture between the last and earlier chambers though more apertures may remain open on the spire	3	Bolli & Saunders (1985)
Globigerinoides conglobatus	Tightly coiled trochospiral, subglobular to subquadrate	Spinose	Cancellate	Primary aperture interiomarginal umbilicallong low asymmetric arch with thin rim. Supplementary sutural apertures on spiral side	3	Kennett & Srinivasan (1983)
Globigerinoides diminutus	Small, trochospiral, equatorial periphery subquadrate	Spinose	Cancellate	Primary aperture interiomarginal umbilical small circular symmetrical arch. Supplementary sutural apertures on spiral side	3	Kennett & Srinivasan (1983)
Globigerinoides extremus	Medium to high trochospiral, final whorl distinctly compressed	Spinose	Cancellate	Primary aperture interiomarginal umbilical distinct arch of medium height. Supplementary sutural apertures on spiral side	3	Kennett & Srinivasan (1983)
Globigerinoides fistulosus	Trochospiral, final chambers compressed and radially elongate with multiple slender digitate extensions	Spinose	Cancellate	Primary aperture interiomarginal umbilical wide arch with rim. Supplementary sutural apertures on spiral side	3	Kennett & Srinivasan (1983)
Globigerinoides mitra	Largehigh trochospiral, spherical to subspherical chambers	Spinose	Cancellate	Interiomarginal umbilical-extraumbilical large semi-circular opening. Supplementary sutural apertures on spiral side	3	Kennett & Srinivasan (1983)

Species name	**General test architecture**	**Spinose / Non-spinose**	**Wall ultra-structure**	**Aperture type**	**Morpho-group**	**Morpho-group reference**
Globigerinoides obliquus	Trochospiral, chambers spherical except final chamber which is compressed in a lateral oblique manner	Spinose	Cancellate	Primary aperture interiomarginal umbilical highwide arch. Supplementary sutural apertures on spiral side	3	Kennett & Srinivasan (1983)
Globigerinoides parawoodi	Low trochospiral, chambers spherical to ovate	Spinose	Cancellate	Primary aperture interiomarginal umbilical medium-sized arch. Supplementary sutural apertures on spiral side	3	Kennett & Srinivasan (1983)
Globigerinoides primordius	Low trochospiral, equatorial profile elongate	Spinose	Cancellate	Primary aperture interiomarginal umbilical low to moderate arch. Supplementary sutural aperture on spiral side	3	Kennett & Srinivasan (1983)
Globigerinoides ruber	Low to high trochospiral, subspherical chambers	Spinose	Cancellate	Primary aperture interiomarginal umbilicalwide arch with rim. Supplementary sutural apertures on spiral side	3	Kennett & Srinivasan (1983)
Globigerinoides sacculifer	Low trochospiral, chambers spherical except final one which is sack like	Spinose	Cancellate	Primary aperture interiomarginal umbilicalwide arch with rim. Supplementary sutural apertures on spiral side	3	Kennett & Srinivasan (1983)
Globigerinoides seigliei	Large, medium to high trochospiral, subquadrate outline	Spinose	Cancellate	Primary aperture interiomarginal umbilicalwide arch with rim. Supplementary sutural apertures on spiral side	3	Kennett & Srinivasan (1983)
Globigerinoides subquadratus	Trochospiral, outline subquadrate, chambers spherical to subspherical	Spinose	Cancellate	Primary aperture interiomarginal umbilicalwide arch with distinct rim. Supplementary sutural apertures on spiral side	3	Kennett & Srinivasan (1983)

Species name	General test architecture	Spinose / Non-spinose	Wall ultra-structure	Aperture type	Morpho-group	Morpho-group reference
Globigerinoides trilobus	Trochospiral, chambers spherical, three in final whorl	Spinose	Cancellate	Primary aperture interiomarginal umbilical low slit. Supplementary sutural aperture on spiral side	3	Kennett & Srinivasan (1983)
Globoconella conoidea	Low trochospiral, umbilical side strongly conical, distinct keel	Non-spinose	Cancellate	Interiomarginal umbilical-extraumbilical low distinct arch with indistinct rim	14	Kennett & Srinivasan (1983)
Globoconella conomiozea	Planoconvex, umbilical side strongly vaulted with acute strong keel	Non-spinose	Cancellate	Interiomarginal extraumbilical high arch, bordered by lip	14	Kennett & Srinivasan (1983)
Globoconella inflata	Low trochospiral, globular, slightly umbilico-convex	Non-spinose	Cancellate	Interiomarginal umbilical-extraumbilical high arch with indistinct rim	7	Kennett & Srinivasan (1983)
Globoconella miozea	Trochospiral, biconvex, equatorial periphery lobulate with keel	Non-spinose	Cancellate	Interiomarginal umbilical-extraumbilical low arch with a thickened rim	14	Kennett & Srinivasan (1983)
Globoconella pliozea	Trochospiral, biconvex, equatorial periphery lobulate with keel, sutures are raised on spiral side	Non-spinose	Cancellate (weakly developed)	Interiomarginal umbilical-extraumbilical slit with a thickened rim	15	Wei (1994)
Globoconella puncticulata	Low trochospiral, umbilico-convexconical	Non-spinose	Cancellate	Interiomarginal umbilical-extraumbilical high arch with rim	7	Kennett & Srinivasan (1983)
Globoconella sphericomiozea	Low trochospiral, umbilico-convexsub-conical	Non-spinose	Cancellate	Interiomarginal umbilical-extraumbilical low arch with rim	7	Kennett & Srinivasan (1983)
Globoconella terminalis	Low trochospiral, spiral side flat, umbilical side distinctly conical, keeled	Non-spinose	Cancellate	Interiomarginal extraumbilical elongate arch bordered by a lip	15	Wei (1987)
Globoquadrina conglomerata	Low trochospiral, equatorial periphery slightly lobate	Non-spinose	Cancellate	Interiomarginal umbilical low arch with umbilical teeth	7	Banner & Blow (1960)

Species name	General test architecture	Spinose / Non-spinose	Wall ultra-structure	Aperture type	Morpho-group	Morpho-group reference
Globoquadrina dehiscens	Umbilico-convex, very low trochospiral	Non-spinose	Coarsely cancellate	Interiomarginal umbilical low arch covered with umbilical tooth	7	Kennett & Srinivasan (1983)
Globorotalia flexuosa	Largetrochospiral, equatorial periphery oval to elongate, final chamber bent sharply to umbilicus, heavy keel	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low arch bordered by plate-like lip	14	Kennett & Srinivasan (1983)
Globorotalia merotumida	Low trochospiral, biconvex, equatorial periphery slightly lobate with distinct keel	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low arch with thick lip	14	Kennett & Srinivasan (1983)
Globorotalia plesiotumida	Lenticular trochospiral, ovate periphery with keel	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low arch bordered by lip	14	Kennett & Srinivasan (1983)
Globorotalia tumida	Biconvex tumid test, trochospiral, ovate periphery with keel	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low arch covered by plate-like lip	14	Kennett & Srinivasan (1983)
Globorotalia ungulata	Small, umbilico-convex, equatorial periphery ovate with thin but distinct keel	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low arch covered by lip	14	Kennett & Srinivasan (1983)
Globorotalia zealandica	Low trochospiral, equatorial periphery quadrilobate, compressed	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical distinct rimmed arch	16	Kennett & Srinivasan (1983)
Globorotaloides eovariabilis	Biconvex, lobate, flattened to slightly elevated trochspiral	Spinose	Coarsely cancellate	Umbilical-extraumbilical arch with broad lip	2	Olsson et al. (2006c)
Globorotaloides hexagonus	Very low trochospiral, spiral side almost flat, equatorial periphery lobulate, chambers spherical	Spinose	Coarsely cancellate	Interiomarginal umbilical-extraumbilical very low arch covered by distinct apertural plate or thick rim	2	Kennett & Srinivasan (1983)
Globorotaloides quadrocameratus	Umbilico-convex, very low trochospiral	Spinose	Coarsely cancellate	Umbilical low opening bordered by narrow thickened lip	2	Olsson et al. (2006c)

Species name	General test architecture	Spinose / Non-spinose	Wall ultra-structure	Aperture type	Morpho-group	Morpho-group reference
Globorotaloides testarugosa	Very low trochospiral, profile subovate to subcircular, slightly lobate	Spinose	Coarsely cancellate	Umbilical-extraumbilical very low arch sometimes covered by small bulla	2	Spezzaferri (1994)
Globorotaloides variabilis	Very low trochospiral, spiral side almost flat, equatorial periphery lobulate, chambers subangular to ovate	Spinose	Coarsely cancellate	Interiomarginal umbilical-extraumbilical very low arch or slit	2	Kennett & Srinivasan (1983)
Globoturborotalita anguliofficinalis	Moderately low trochosprial globular with lobulate outline	Spinose	Cancellate	Umbilical low round arch bordered by narrow lip	2	Olsson et al. (2006a)
Globoturborotalita apertura	Low trochospiral, chambers spherical to subspherical	Spinose	Cancellate	Umbilical very large semi-circular arch with distinct rim	2	Kennett & Srinivasan (1983)
Globoturborotalita bassriverensis	Moderate to low trochospiral, globular	Spinose	Cancellate	Umbilical rounded arch bordered by a narrow lip that is sometimes thickened	2	Olsson et al. (2006a)
Globoturborotalita bollii	Small, compact, trochospiral, chambers spherical to ovate	Spinose	Cancellate	Primary aperture interiomarginal umbilical small almost circular opening. Supplementary sutural aperture on spiral side	3	Kennett & Srinivasan (1983)
Globoturborotalita brazieri	Low trochospiral, subquadrate outline	Spinose	Hispid	Umbilical very high arch with a thick rim	2	Kennett & Srinivasan (1983)
Globoturborotalita connecta	Low trochospiral, compacte, quatorial periphery trilobate	Spinose	Hispid	Low arch with faint rim	2	Kennett & Srinivasan (1983)
Globoturborotalita decoraperta	Compact, low to medium-high trochospiral, outline lobulate, chambers spherical to subspherical	Spinose	Cancellate	Interiomarginal umbilical large semicirular bordered by a rim	2	Kennett & Srinivasan (1983)
Globoturborotalita gnaucki	Moderately low trochosprial, globular with lobulate outline	Spinose	Cancellate	Umbilical rounded arch bordered by a thin thickened rim	2	Olsson et al. (2006a)

Species name	General test architecture	Spinose / Non-spinose	Wall ultra-structure	Aperture type	Morpho-group	Morpho-group reference
Globoturborotalita kennetti	Low spired, spherical to subspherical chambers	Spinose	Cancellate	Primary aperture centred over suture of final and penultimate chambers. Supplementary sutural apertures on spiral side	3	Kennett & Srinivasan (1983)
Globoturborotalita labiacrassata	Low trochospiral, profile subcircular, slightly lobulate	Spinose	Cancellate	High semicircular arch bordered by thick distinct rim	2	Spezzaferri (1994)
Globoturborotalita martini	Moderately low trochosprial, globular with lobulate outline	Spinose	Cancellate	Umbilical rounded arch bordered by a thickened rim	2	Olsson et al. (2006a)
Globoturborotalita nepenthes	Compactly coiled except for last-formed protuding chamber, low to high spire	Spinose	Cancellate	Broad arch at the umbilical edge of the final chamber bordered by thickened rim	2	Kennett & Srinivasan (1983)
Globoturborotalita ouachitaensis	Moderately low trochosprial, globular with lobulate outline	Spinose	Cancellate	Umbilical rounded arch bordered by a thickened rim	2	Olsson et al. (2006a)
Globoturborotalita rubescens	Small, trochospiral, equatorial periphery lobulate, chambers spherical to subspherical	Spinose	Cancellate	Umbilical small rounded opening bordered by a distinct rim	2	Kennett & Srinivasan (1983)
Globoturborotalita tenella	Small, low trochospiral, chambers spherical	Spinose	Cancellate	Primary aperture umbilical large almost circular opening with distinct rim small supplementary aperture on spiral side	2	Kennett & Srinivasan (1983)
Globoturborotalita woodi	Low trochospiral, equatorial periphery quadrilobate, chambers spherical to subspherical	Spinose	Cancellate	Interiomarginal umbilical high arch bordered by a thick rim	2	Kennett & Srinivasan (1983)
Guembelitrioides nuttalli	High spired trochospiral to helicospiral, globular	Spinose	Cancellate	Umbilical high arch supplementary apertures present along sutures on spiral side	2	Olsson et al. (2006c)

Species name	**General test architecture**	**Spinose / Non-spinose**	**Wall ultra-structure**	**Aperture type**	**Morpho-group**	**Morpho-group reference**
Hantkenina alabamensis	Planispiral ,compact, biumbilicate, chambers tubulospinose	Probably non-spinose	Smooth	Equatorial high arch which is narrow at the top becoming broader at the base bordered by imperforate lip	10	Coxall & Pearson (2006)
Hantkenina australis	Planispiral, laterally compressed, biumbilicate, chambers tubulospinose	Probably non-spinose	Smooth	Equatorial high arch which is narrow at the top becoming broader at the base bordered by imperforate lip	10	Coxall & Pearson (2006)
Hantkenina compressa	Planispiral, laterally compressed, biumbilicate, chambers tubulospinose	Probably non-spinose	Smooth	Equatorial high narrow arch flaring into lateral lobes at the base bordered by wide flaring lip	10	Coxall & Pearson (2006)
Hantkenina dumblei	Planispiral, involute, laterally compressed, biumbilicate, chambers tubulospinose	Probably non-spinose	Smooth	Equatorial elongated arch widening towards base into weak apertural lobes bordered by imperforate flaring lip	10	Coxall & Pearson (2006)
Hantkenina lehneri	Planispiral, involute, biumbilicate, chambers tubulospinose	Probably non-spinose	Smooth	Equatorial elongated arch bordered by well-pronounced crenulated pustluose lip	10	Coxall & Pearson (2006)
Hantkenina liebusi	Planispiral, involute, laterally compressed, biumbilicate, chambers tubulospinose	Probably non-spinose	Smooth	Equatorial elongated arch bordered two-thirds of the way up by a crenulated pustulose lip	10	Coxall & Pearson (2006)
Hantkenina mexicana	Planispiral, evolute, biumbilicate, chambers tubulospinose	Probably non-spinose	Smooth	Equatorial elongated arch bordered by flaring often crenulated and pustulose lip	10	Coxall & Pearson (2006)
Hantkenina nanggulanensis	Planispiral, biumbilicate, strongly inflated, chambers tubulospinose	Probably non-spinose	Smooth	Equatorial high narrow arch flaring into lateral lobes at the base or open and triangular	10	Coxall & Pearson (2006)

Species name	General test architecture	Spinose / Non-spinose	Wall ultra-structure	Aperture type	Morpho-group	Morpho-group reference
Hantkenina primitiva	Planispiral, somewhat evolute, laterally compressed, biumbilicate, chambers tubulospinose	Probably non-spinose	Smooth	Equatorial high narrow arch flaring into lateral lobes at the base bordered by wide flaring lip	10	Coxall & Pearson (2006)
Hantkenina singanoae	Planispiral to pseudo-planispiral, laterally compressed, biumbilicate, chambers proto-tubulospinose	Probably non-spinose	Smooth, weakly cancellate	Equatorial high arch with a smooth broad lip	10	Coxall & Pearson (2006)
Hedbergella holmdelensis	Biconvex, very low trochospiral	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low arch with narrow lip	7	Olsson et al. (1999)
Hedbergella monmouthensis	Umbilico-convex, very low trochospiral	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low arch with distinct narrow lip	7	Olsson et al. (1999)
Hirsutella bermudezi	Very small, low trochospiral, equatorial periphery subcirular, slightly biconvex	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low arch with distinct thin lip	16	Kennett & Srinivasan (1983)
Hirsutella challengeri	Low trochospiral, unequally biconvex, equatorial periphery lobate	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical distinct arch with a prominent lip	16	Kennett & Srinivasan (1983)
Hirsutella cibaoensis	Low trochospiral, biconvex, equatorial periphery subquadrate	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low arch bordered by a thin lip	16	Kennett & Srinivasan (1983)
Hirsutella evoluta	As *H. margaritae* but larger with a more symmetrical profile	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low slit bordered by a pronounced lip	16	D. R. M. Stewart unpublished data
Hirsutella gigantea	Large, medium to low trochospiral, equatorial periphery slightly lobulate with keel-like rim	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low slit bordered by a pronounced lip	14	D. R. M. Stewart unpublished data

Species name	**General test architecture**	**Spinose / Non-spinose**	**Wall ultra-structure**	**Aperture type**	**Morpho-group**	**Morpho-group reference**
Hirsutella hirsuta	Large, high trochospiral, highly convex on spiral side, concave on umbilical side	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low arch bordered by a thin lip	15	Kennett & Srinivasan (1983)
Hirsutella juanai	Small, very low trochospiral, biconvex, equatorial periphery slightly lobate	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low arch or slit bordered by a thin lip	16	Kennett & Srinivasan (1983)
Hirsutella margaritae	Low trochospiral, compressed, spiral side convex, umbilical side concave with thin keel	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low slit bordered by a pronounced lip	14	Kennett & Srinivasan (1983)
Hirsutella praemargaritae	Medium to low trochospiral, equatorial periphery slightly lobulate with keel-like rim	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low slit bordered by a pronounced lip	14	D. R. M. Stewart unpublished data
Hirsutella praescitula	Low trochospiral, biconvex, equatorial periphery subangular	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low arch bordered by a thin lip	16	Kennett & Srinivasan (1983)
Hirsutella primitiva	As *H. margaritae* but smaller and lacking a complete keel	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low slit bordered by a pronounced lip	14	D. R. M. Stewart unpublished data
Hirsutella scitula	Medium to low trochospiral, equatorial periphery slightly lobulate with keel-like rim	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low slit bordered by a pronounced lip	14	Kennett & Srinivasan (1983)
Hirsutella theyeri	Large, thin, planoconvex to biconvex, markedly flaring chambers in final whorl with a thin discontinous peripheral keel	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low arch bordered by a distinct but thin lip	14	Kennett & Srinivasan (1983)
Igorina albeari	Biconvex, trochospiral	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low slit with distinct thin lip	12	Olsson et al. (1999)

Species name	General test architecture	Spinose / Non-spinose	Wall ultra-structure	Aperture type	Morpho-group	Morpho-group reference
Igorina anapetes	Low trochospiral, subcircular, subtriangular chambers	Non-spinose	Muricate	Continous circum-umbilical low arching slit	7	Berggren et al. (2006a)
Igorina broedermanni	Umbilico-convex to weakly biconvex, low trochospiral	Non-spinose	Smooth	Low slit extending towards peripheral margin	7	Berggren et al. (2006a)
Igorina lodoensis	Biconvex, low trochospiral	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical arch	7	Berggren et al. (2006a)
Igorina pusilla	Biconvex, low trochospiral	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low arch with narrow lip	7	Olsson et al. (1999)
Igorina tadjikistanensis	Biconvex, trochospiral	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low arch bordered by a thin lip	7	Olsson et al. (1999)
Menardella archeomenardii	Lenticular, low trochospiral, prominent keel and densely perforate surface	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low-arched slit with distinct lip	14	Kennett & Srinivasan (1983)
Menardella exilis	Lenticular, low trochospiral, prominent keel and densely perforate surface	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low-arched slit	14	Kennett & Srinivasan (1983)
Menardella fimbriata	Lenticular, low trochospiral, prominent keel and densely perforate surface	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low-arched slit	14	Kennett & Srinivasan (1983)
Menardella limbata	Lenticular, low trochospiral, prominent keel and densely perforate surface	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low-arched slit with lip	14	Kennett & Srinivasan (1983)
Menardella menardii	Lenticular, low trochospiral, prominent keel and densely perforate surface	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low-arched slit with thick lip	14	Kennett & Srinivasan (1983)
Menardella miocenica	Lenticular, planoconvex, low trochospiral, prominent keel and densely perforate surface	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low-arched slit with thin lip	14	Kennett & Srinivasan (1983)
Menardella multicamerata	Lenticular, low trochospiral, prominent keel and densely perforate surface	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low-arched slit with distinct lip	14	Kennett & Srinivasan (1983)

Species name	General test architecture	Spinose / Non-spinose	Wall ultra-structure	Aperture type	Morpho-group	Morpho-group reference
Menardella pertenius	Lenticular, low trochospiral, prominent keel and densely perforate surface	Non-spinose	Smooth	Umbilical-extraumbilical low-arched slit with flaring lip forming a thin plate extending over the umbilical area	14	Kennett & Srinivasan (1983)
Menardella praemenardii	Lenticular, low trochospiral, prominent keel and densely perforate surface	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low-arched slit with distinct lip	14	Kennett & Srinivasan (1983)
Menardella pseudomiocenica	Lenticular, low trochospiral, prominent keel and densely perforate surface	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low-arched slit with lip	14	Kennett & Srinivasan (1983)
Morozovella acuta	Umbilico-convex, trochospiral, keeled periphery	Non-spinose	Muricate	Interiomarginal umbilical-extraumbilical slit with triangular circumumbilical teeth	18	Olsson et al. (1999)
Morozovella acutispira	Biconvex, trochospiral, keeled periphery	Non-spinose	Muricate	Interiomarginal umbilical-extraumbilical low arch	18	Olsson et al. (1999)
Morozovella aequa	Umbilico-convex, low trochospiral, keeled periphery	Non-spinose	Muricate	Interiomarginal umbilical-extraumbilical low slit	18	Olsson et al. (1999)
Morozovella allisonensis	Low to medium trochospiral, subcircular	Non-spinose	Muricate	Interiomarginal umbilical-extraumbilical low arch	18	Berggren & Pearson (2006)
Morozovella angulata	Umbilico-convex, trochospiral, keeled periphery	Non-spinose	Muricate	Interiomarginal umbilical-extraumbilical low arch with weakly developed lip	18	Olsson et al. (1999)
Morozovella apanthesma	Umbilico-convex, low trochospiral, weakly keeled periphery	Non-spinose	Muricate	Interiomarginal umbilical-extraumbilical arch with narrow continuous intraperiumbilic al lip	18	Olsson et al. (1999)
Morozovella aragonensis	Umbilico-convex, low trochospiral, keeled periphery	Non-spinose	Muricate	Umbilical-extraumbilical low arch extending to peripheral margin	19	Berggren & Pearson (2006)
Morozovella caucasica	Umbilico-convex, low trochospiral, keeled periphery	Non-spinose	Muricate	Umbilical-extraumbilical low slit extending to periphery	19	Berggren & Pearson (2006)

Species name	General test architecture	Spinose / Non-spinose	Wall ultra-structure	Aperture type	Morpho-group	Morpho-group reference
Morozovella conicotruncata	Umbilico-convex, low trochospiral, keeled periphery	Non-spinose	Muricate	Interiomarginal umbilical-extraumbilical low slit	18	Olsson et al. (1999)
Morozovella crater	Umbilico-convex, low trochospiral, keeled periphery	Non-spinose	Muricate	Interiomarginal umbilical-extraumbilical low slit with thin lip	19	Berggren & Pearson (2006)
Morozovella edgari	Low to moderately conical trochospiral, weakly lobulate peripheral outline	Non-spinose	Muricate	Interiomarginal umbilical-extraumbilical low arch	19	Berggren & Pearson (2006)
Morozovella formosa	Umbilico-convex, trochospiral	Non-spinose	Muricate	Umbilical-extraumbilical low arch extending to periphery	19	Berggren & Pearson (2006)
Morozovella gracilis	Umbilico-convex, low trochospiral	Non-spinose	Muricate	Interiomarginal umbilical-extraumbilical low arch	18	Olsson et al. (1999)
Morozovella lensiformis	Biconvex to umbilico-convex, low trochospiralkeeled periphery	Non-spinose	Muricate	Umbilical-extraumbilical low slit extending to periphery	19	Berggren & Pearson (2006)
Morozovella marginodentata	Biconvex, low trochospiral	Non-spinose	Muricate	Umbilical-extraumbilical low arch	18	Berggren & Pearson (2006)
Morozovella occlusa	Biconvex to umbilico-convex, trochospiral, keeled periphery	Non-spinose	Muricate	Interiomarginal umbilical-extraumbilical arch with distinct lip	18	Olsson et al. (1999)
Morozovella pasionensis	Umbilico-convex, low trochospiral, keeled periphery	Non-spinose	Muricate	A low slit extending al.ong peri-intraumbilical margin to peripheral margin of last chamber	18	Olsson et al. (1999)
Morozovella praeangulata	Umbilico-convex, trochospiral	Non-spinose	Muricate	Interiomarginal umbilical-extraumbilical slit with intraperiumbilical lip	18	Olsson et al. (1999)
Morozovella subbotinae	Umbilico-convex, low trochospiral, keeled periphery	Non-spinose	Muricate	Interiomarginal umbilical-extraumbilical small slit with weak lip	18	Olsson et al. (1999)
Morozovella velascoensis	Umbilico-convex, trochospiral, keeled periphery	Non-spinose	Muricate	Interiomarginal umbilical-extraumbilical low arch	19	Olsson et al. (1999)

Species name	General test architecture	Spinose / Non-spinose	Wall ultra-structure	Aperture type	Morpho-group	Morpho-group reference
Morozovelloides bandyi	Planoconvex to lenticular, low trochospiral, keeled periphery	Non-spinose	Muricate	Umbilical-extraumbilical low flat arch	17	Pearson & Berggren (2006)
Morozovelloides coronatus	Low trochospiral, spiral side weakly convex, umbilical side distinctly convex, keeled periphery	Non-spinose	Muricate	Interiomarginal umbilical-extraumbilical low slit	19	Pearson & Berggren (2006)
Morozovelloides crassatus	Low trochospiral, asymmetrically biconvex, elongate ovalweakly to moderately lobulate, keeled periphery	Non-spinose	Muricate	Interiomarginal umbilical-extraumbilical low slit	17	Pearson & Berggren (2006)
Morozovelloides lehneri	Low trochospiral, biconvex, elongate oval, strongly lobulate, strongly fimbriate keeled periphery	Non-spinose	Muricate	Interiomarginal umbilical-extraumbilical low slit	17	Pearson & Berggren (2006)
Neogloboquadrina acostaensis	Low trochospiral, equatorial periphery strongly lobulate	Non-spinose	Cancellate	Interiomarginal umbilical-extraumbilical low arch with distinct rim or plate covering much of the umbilicus	7	Kennett & Srinivasan (1983)
Neogloboquadrina continuosa	Low trochospiral, equatorial periphery lobulate, chambers subspherical to ovate	Non-spinose	Cancellate	Interiomarginal umbilical-extraumbilical low arch bordered by a distinct rim	7	Kennett & Srinivasan (1983)
Neogloboquadrina dutertrei	Trochospiral, globose, spiral side flat to slightly convex	Non-spinose	Cancellate	Umbilical-extraumbilical broad deep opening with tooth-like umbilical plates often present	7	Kennett & Srinivasan (1983)
Neogloboquadrina humerosa	Low trochospiral, equatorial periphery lobulate, chambers ovate	Non-spinose	Cancellate	Interiomarginal umbilical-extraumbilical low to medium arch with distinct rim	7	Kennett & Srinivasan (1983)

Species name	**General test architecture**	**Spinose / Non-spinose**	**Wall ultra-structure**	**Aperture type**	**Morpho-group**	**Morpho-group reference**
Neogloboquadrina pachyderma	Low trochospiral, lobulate rounded periphery	Non-spinose	Cancellate	Interiomarginal umbilical-extraumbilical low arch with a thick apertural rim	7	Kennett & Srinivasan (1983)
Orbulina suturalis	Almost spherical, final chamber not entirely enveloping earlier test	Spinose	Hispid	Areal aperturessupple mentary apertures al.ong sutures separating earlier and final chambers	4	Kennett & Srinivasan (1983)
Orbulina universa	Completely spherical with final chamber entirely enveloping earlier test	Spinose	Hispid	Numerous small openings of two distinct sizes	4	Kennett & Srinivasan (1983)
Orbulinoides beckmanni	Low trochospiral becoming streptospiral with final chamber hemispherical, almost spherical	Spinose	Cancellate	Primary aperture an umbilical arch later replaced by smaller multiple irregularly arched sutural apertures. Bulla may be present	4	Premoli Silva et al. (2006)
Paragloborotalia acrostoma	Low trochospiral, equatorial periphery subquadrate to oval	Spinose	Coarsely cancellate	Interiomarginal umbilical-extraumbilical high arch bordered by a rim	2	Kennett & Srinivasan (1983)
Paragloborotalia bella	Low trochospiral, equatorial periphery quinquelobate, chambers ovate	Spinose	Coarsely cancellate	Interiomarginal umbilical-extraumbilical low arch with a thick lip	2	Kennett & Srinivasan (1983)
Paragloborotalia griffinoides	Very low trochospiral, globular	Spinose	Coarsely cancellate	Umbilical-extraumbilical high arch bordered by narrow or thickened continuous lip	2	Olsson et al. (2006c)
Paragloborotalia incognita	Small, low trochospiral, equatorial periphery quadrilobate	Spinose	Coarsely cancellate	Interiomarginal umbilical-extraumbilical fairly high arch bordered by a thick rim	2	Kennett & Srinivasan (1983)
Paragloborotalia kugleri	Low trochospiral, equatorial periphery slightly lobate	Non-spinose	Cancellate	Interiomarginal umbilical-extraumbilicaldi stinct arch with lip	16	Kennett & Srinivasan (1983)

Species name	General test architecture	Spinose / Non-spinose	Wall ultra-structure	Aperture type	Morpho-group	Morpho-group reference
Paragloborotalia mayeri	Low trochospiral, equatorial periphery ovate	Spinose	Coarsely cancellate	Interiomarginal umbilical-extraumbilical fairly high arch bordered by a thick rim	2	Kennett & Srinivasan (1983)
Paragloborotalia nana	Very low trochospiral, globular	Spinose	Coarsely cancellate	Umbilical-extraumbilical bordered by narrow or thickened continuous lip	2	Olsson et al. (2006c)
Paragloborotalia opima	Very low trochospiral, compact, profile subquadrate and slightly lobate	Spinose	Coarsely cancellate	Interiomarginal umbilical-extraumbilical low to moderately high arch sometimes bordered by a rim	2	Spezzaferri (1994)
Paragloborotalia pseudokugleri	Low trochospiral, profile subcircular and lobate	Non-spinose	Cancellate	Umbilical-extraumbilical low arch	16	Spezzaferri (1994)
Paragloborotalia semivera	Low trochospiral, equatorial periphery ovate, chambers spherical	Spinose	Coarsely cancellate	Interiomarginal umbilical-extraumbilical low arch bordered by a rim	2	Kennett & Srinivasan (1983)
Paragloborotalia siakensis	Low trochospiral, equatorial periphery ovate, chambers subspherical	Spinose	Coarsely cancellate	Interiomarginal umbilical-extraumbilical low elongate arch bordered by a distinct rim	2	Kennett & Srinivasan (1983)
Parasubbotina aff*_pseudobulloides*	Umbilico-convex, low trochospiral	Spinose	Cancellate (weakly developed)	Umbilical-extraumbilical high arch with continuous thin lip	2	Olsson et al. (1999)
Parasubbotina eoclava	Very low trochospiral	Spinose	Cancellate	Interiomarginal umbilical-extraumbilical high arch bordered by well-developed asymmetric flange	2	Olsson et al. (2006c)
Parasubbotina griffinae	Biconvex, very low trochospiral	Spinose	Cancellate	Umbilical-extraumbilical low arch with narrow continuous lip	2	Olsson et al. (2006c)
Parasubbotina inaequispira	Very low trochospiral, globular	Spinose	Cancellate	Umbilical-extraumbilical low arch bordered by narrow continuous lip	2	Olsson et al. (2006c)

Species name	General test architecture	Spinose / Non-spinose	Wall ultra-structure	Aperture type	Morpho-group	Morpho-group reference
Parasubbotina prebetica	Very low trochospiral, symmetrical elongate chambers	Spinose	Cancellate	Umbilical-extraumbilical low arch bordered by broad lip	2	Olsson et al. (2006c)
Parasubbotina pseudobulloides	Umbilico-convex, low trochospiral	Spinose	Cancellate	Interiomarginal umbilical-extraumbilical high rounded arch with narrow lip	2	Olsson et al. (1999)
Parasubbotina pseudowilsoni	Very low trochospiral, globular lobulate outline	Spinose	Cancellate	Umbilical low arch bordered by narrow lip of varying thickness	2	Olsson et al. (2006c)
Parasubbotina varianta	Umbilico-convex, very low trochospiral	Spinose	Cancellate	Umbilical-extraumbilical rounded high arch bordered by fairly broad continuous lip	2	Olsson et al. (1999)
Parasubbotina variospira	Moderate to high trochospire	Spinose	Cancellate	Interiomarginal umbilical-extraumbilical arch teeth common	2	Olsson et al. (1999)
Planoglobanomalina pseudoalgeriana	Evolute to partially involute, asymmetrical to fully planispiral	Non-spinose	Smooth	Equatorial asymmetric to symmetric oval opening bordered by a broad lip	9	Olsson & Hemleben (2006)
Planorotalites capdevilensis	Weakly to moderately biconvex, trochospiral, keeled periphery	Non-spinose	Muricate	Umbilical-extraumbilical arch bordered by distinct lip	17	Berggren et al. (2006a)
Planorotalites pseudoscitula	Biconvex, low trochospiral, keeled periphery	Non-spinose	Muricate	Umbilical-extraumbilical low slit with distinct lip that extends to periphery	17	Berggren et al. (2006a)
Praemurica inconstans	Umbilico-convex, very low trochospiral	Non-spinose	Cancellate	Interiomarginal umbilical-extraumbilical slit with distinct lipped rim	7	Olsson et al. (1999)
Praemurica lozanoi	Asymmetrically biconvex, trochospiral	Non-spinose	Cancellate	Interiomarginal umbilical high arch	7	Berggren et al. (2006a)
Praemurica pseudoinconstans	Biconvex low trochospiral	Non-spinose	Cancellate (weakly developed)	Umbilical high rounded arch bordered by narrow lip broadening towards umbilicus	7	Olsson et al. (1999)

Species name	General test architecture	Spinose / Non-spinose	Wall ultra-structure	Aperture type	Morpho-group	Morpho-group reference
Praemurica taurica	Umbilico-convex, low trochospiral	Non-spinose	Cancellate (weakly developed)	Umbilical-extraumbilical low to high arch bordered by narrow lip broadening towards umbilicus	7	Olsson et al. (1999)
Praemurica uncinata	Umbilico-convex, low trochospiral	Non-spinose	Cancellate (weakly developed)	Interiomarginal extraumbilical-umbilical low arch exending to peripheral margin	7	Olsson et al. (1999)
Praeorbulina circularis	Subspherical to spherical	Spinose	Cancellate	Numerous small apertures along basal suture	4	Kennett & Srinivasan (1983)
Praeorbulina curva	Subspherical to spherical	Spinose	Cancellate	Four-eight small sutural supplementary apertures	4	Kennett & Srinivasan (1983)
Praeorbulina glomerosa	Subspherical to spherical	Spinose	Cancellate	Several small cresentric and slit-like openings along basal suture	4	Kennett & Srinivasan (1983)
Praeorbulina sicanus	Subspherical to spherical	Spinose	Cancellate	Two-three irregular narrow slits at the base of the final chamber	4	Kennett & Srinivasan (1983)
Protentella nicobarensis	Small, low trochospiral, outline deeply lobulate, later chambers clavate	Spinose	Cancellate	Umbilical-extraumbilical nearly circular arch varying in height bordered by distinct uniform imperforate lip	5	Kennett & Srinivasan (1983)
Protentella prolixa	Small, almost planispiral, biumbilicate, later chambers becoming clavate	Spinose	Cancellate	Nearly equatorial basal high arch bordered by a distinct thick lip	6	Kennett & Srinivasan (1983)
Protentelloides dalhousiei	Extremely low trochospiral becoming planispiral in final whorl	Spinose	Cancellate	Has two types of aperture (1) *Hantkenina* type (2) large low-arched slit with a distinct rim	6	Zhang & Scott (1995)
Protentelloides primitiva	Extremely low trochospiral becoming planispiral in final whorl	Spinose	Cancellate	Interiomarginal umbilical-extraumbilical slit-like opening	6	Zhang & Scott (1995)
Pseudoglobigerinella bolivariana	Nearly involute, asymmetrically planispiral	Spinose	Cancellate	Asymmetrical equatorial low to high arch with imperforate rim	6	Olsson et al. (2006c)

Species name	General test architecture	Spinose / Non-spinose	Wall ultra-structure	Aperture type	Morpho-group	Morpho-group reference
Pseudohastigerina micra	Involute, planispiral	Non-spinose	Smooth	Equatorial symmetrical high curved arch with narrow lip	9	Olsson & Hemleben (2006)
Pseudohastigerina naguewichiensis	Involute, planispiral	Non-spinose	Smooth	Equatorial moderately high arch bordered by thick prominent lip	9	Olsson & Hemleben (2006)
Pseudohastigerina sharkriverensis	Involute, planispiral	Non-spinose	Smooth	Equatorial low arch bordered by narrow lip commonly bipartite in adult specimens	9	Olsson & Hemleben (2006)
Pseudohastigerina wilcoxensis	Involute, planispiral	Non-spinose	Smooth	Symmetrical to slightly asymmetic high circular arch with narrow lip or matched bipartite openings	9	Olsson & Hemleben (2006)
Pulleniatina finalis	Involute, planispiral with a very broadly rounded periphery	Non-spinose	Smooth	Extra-umbilical high arch	7	Bolli & Saunders (1985)
Pulleniatina obliquiloculata	Trochospiral becoming streptospiral, very smooth surface, globular	Non-spinose	Smooth	Umbilical-extraumbilical low archoften pustulate	7	Kennett & Srinivasan (1983)
Pulleniatina praecursor	Trochospiral intially becoming streptospiral, broadly rounded chambers, spherical test covered in thick cortex	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilicala medium arch at the base of the final chamber	7	Kennett & Srinivasan (1983)
Pulleniatina praespectabilis	Convexly rounded initial portion of the trochospire as seen in lateral view, with a well rounded pseudo keel	Non-spinose	Smooth	Extraumbilical medium to low arch without lip or rim	7	Bolli & Saunders (1985)
Pulleniatina primalis	Trochospiral intially becoming streptospiral, broadly rounded chambers, spherical test covered in thick cortex	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low arch at the base of the final chamber	7	Kennett & Srinivasan (1983)

Species name	General test architecture	Spinose / Non-spinose	Wall ultra-structure	Aperture type	Morpho-group	Morpho-group reference
Pulleniatina spectabilis	Planoconvex, low to medium trochospiral, later becoming streptospiral, with pseudocarinate periphery	Non-spinose	Smooth	Extraumbilical medium to low arch without lip or rim	8	Kennett & Srinivasan (1983)
Sphaeroidinella dehiscens	Large, trochospiral, equatorial periphery ovoid or spherical with smooth secondary cortex	Non-spinose	Cancellate with smooth cortex	Primary apertureinteriom arginal umbilical two sutural supplementary apertures bordered by crenulated lip	7	Kennett & Srinivasan (1983)
Sphaeroidinellopsis disjuncta	Low trochospiral, equatorial periphery trilobate to quadrilobate, chambers spherical to ovate	Non-spinose	Cancellate	Interiomarginal umbilical bordered by thickened rim	7	Kennett & Srinivasan (1983)
Sphaeroidinellopsis kochi	Large, compressed low trochospiral, equatorial periphery lobulate, chambers spherical to subspherical	Non-spinose	Cancellate	Umbilical large irregular opening with a thickened lip	7	Kennett & Srinivasan (1983)
Sphaeroidinellopsis paenedehiscens	Large, low trochospiral, ovate to smoothly rounded periphery, sutures obscured by thick secondary cortex	Non-spinose	Cancellate with smooth cortex	An elongate umbilical opening following the line of suture of final chamber bordered by crenulated lip which is an extension of secondary cortex	7	Kennett & Srinivasan (1983)
Sphaeroidinellopsis seminulina	Compact, low trochospiral, subglobular, sutures obscured by secondary cortex	Non-spinose	Cancellate with smooth cortex	Umbilical elongate opening bordered by thickened crenulated rim	7	Kennett & Srinivasan (1983)
Subbotina angiporoides	Non-umbilicate, spherical, quadrilobate	Spinose	Cancellate	A low indistinct interiomarginal slit bordered by a thick lip	2	Olsson et al. (2006a)
Subbotina cancellata	Low trochosprial, tightly coiled	Spinose	Coarsely cancellate	Umbilically directed aperture bordered by broad somewhat irregular lip	2	Olsson et al. (1999)

Species name	**General test architecture**	**Spinose / Non-spinose**	**Wall ultra-structure**	**Aperture type**	**Morpho-group**	**Morpho-group reference**
Subbotina corpulenta	Moderately high trochospiral with lobulate outline	Spinose	Cancellate	Umbilical generally without lip	2	Olsson et al. (2006a)
Subbotina crociapertura	Low trochospiral, globular with oval outline	Spinose	Cancellate	Umbilical-extraumbilical high circular arch bordered by a prominent lip	2	Olsson et al. (2006a)
Subbotina eocaena	Low trochospiral, globular	Spinose	Cancellate	Umbilical-extraumbilical high circular arch bordered by thin irregular lip	2	Olsson et al. (2006a)
Subbotina gortanii	High trochospiral, globular outline	Spinose	Cancellate	Umbilical bordered by a thickened narrow rim	2	Olsson et al. (2006a)
Subbotina hagni	Biconvex, low trochosprial	Spinose	Cancellate	Umbilical-extraumbilical low arch with thin irregular lip	2	Olsson et al. (2006a)
Subbotina hornibrooki	Low trochospiral, globular	Spinose	Cancellate	Umbilical bordered by narrow continuous lip	2	Olsson et al. (2006a)
Subbotina jacksonensis	Low trochospiral, globular with oval outline	Spinose	Cancellate	Umbilical and may be obscured by ultimate chamber	2	Olsson et al. (2006a)
Subbotina linaperta	Low trochospiral, globular	Spinose	Cancellate	Umbilical-extraumbilical bordered by thin even lip	2	Olsson et al. (2006a)
Subbotina patagonica	Globular, very low trochospiral	Spinose	Cancellate	Umbilical rounded arch bordered by a thickened rim that may display a lip	2	Olsson et al. (2006a)
Subbotina roesnaesensis	Very low trochospiral, tripartite	Spinose	Cancellate	Umbilical low arch with narrow lip of varying width	2	Olsson et al. (2006a)
Subbotina senni	Moderately elevated trochospiral, globular	Spinose	Cancellate	Umbilical bordered by thickened rim not always visible	2	Olsson et al. (2006a)
Subbotina sp1		Spinose	Cancellate		2	B. S. Wade & P. N. Pearson personal communication

Species name	General test architecture	Spinose / Non-spinose	Wall ultra-structure	Aperture type	Morpho-group	Morpho-group reference
Subbotina sp2		Spinose	Cancellate		2	B. S. Wade & P. N. Pearson personal communication
Subbotina triangularis	Low trochospiral, triangular	Spinose	Cancellate	Umbilical to slightly extraumbilical with broad lip	2	Olsson et al. (1999)
Subbotina triloculinoides	Trochospiral, trilobate	Spinose	Cancellate	Umbilical to slightly extraumbilical with well-developed delicately notched lip	2	Olsson et al. (1999)
Subbotina trivialis	Umbilico-convex, low trochospiral	Spinose	Cancellate	Umbilical low arch with thin lip	2	Olsson et al. (1999)
Subbotina utilisindex	Low trochosprial, trilobateglobular	Spinose	Cancellate	Low interiomarginal umbilical-extraumbilical slit bordered by a narrow lip	2	Olsson et al. (2006a)
Subbotina velascoensis	Trochospiral	Spinose	Cancellate	Umbilical-extraumbilical slit bordered by thin squared-off lip that does not extend full length of aperture	2	Olsson et al. (1999)
Subbotina yeguaensis	Moderately elevated trochospiral, globular	Spinose	Cancellate	Umbilical low round opening bordered by broad lip	2	Olsson et al. (2006a)
Truncorotalia cavernula	Small, very low trochospiral, spiral side almost flat, umbilical side distinctly convex	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical high rounded arch with a distinct rim	15	Kennett & Srinivasan (1983)
Truncorotalia crassaconica	Ventroconical, steep conical umbilical side, keeled, heavily pustulate test	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low-arched slit	15	D. R. M. Stewart unpublished data
Truncorotalia crassaformis	Low trochospiral, spiral side almost flat, umbilical side strongly convex	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low-arched slit bordered by lip	15	Kennett & Srinivasan (1983)
Truncorotalia crassula	Very low trochospiral, spiral side almost flat, umbilical side convex	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low arch with lip	15	Kennett & Srinivasan (1983)

Species name	General test architecture	Spinose / Non-spinose	Wall ultra-structure	Aperture type	Morpho-group	Morpho-group reference
Truncorotalia excelsa	Ventroconical, steep conical umbilical side, spiral side flat to slightly concave, acutely keeled, heavily pustulate test	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low-arched slit	15	D. R. M. Stewart unpublished data
Truncorotalia hessi	As *T. crassaformis* but more subquadrangular in equatorial view and final chamber is more reduced	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low-arched slit bordered by lip	15	D. R. M. Stewart unpublished data
Truncorotalia oceanica	As *T. crassaformis* but has greater chamber rounding and a less conical umbilical side than *T. ronda*	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low-arched slit bordered by lip	15	D. R. M. Stewart unpublished data
Truncorotalia pachytheca	As *T. truncatulinoides* but with more rounded chambers and less conical umbilical side	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low arch bordered by lip	15	D. R. M. Stewart unpublished data
Truncorotalia ronda	As *T. crassaformis* but more rounded peripheral margin and relatively thickened test	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low-arched slit bordered by lip	15	D. R. M. Stewart unpublished data
Truncorotalia tenuitheca	As *T. tosaensis* with sharper curvature and less incision of spiral sutures	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low-arched slit bordered by lip	15	D. R. M. Stewart unpublished data
Truncorotalia tosaensis	Low trochospiral, strongly umbilico-convex with flat spiral side, commonly 5 chambers in final whorl	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low-arched slit bordered by lip	15	Kennett & Srinivasan (1983)
Truncorotalia truncatulinoides	Low trochospiral, strongly umbilico-convex with distinct keel	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low arch bordered by lip	15	Kennett & Srinivasan (1983)
Truncorotalia viola	As *T. crassaformis* but has keel and more angular chambers	Non-spinose	Smooth	Interiomarginal umbilical-extraumbilical low-arched slit bordered by lip	15	D. R. M. Stewart unpublished data

Species name	General test architecture	Spinose / Non-spinose	Wall ultra-structure	Aperture type	Morpho-group	Morpho-group reference
Turborotalia altispiroides	High trochospiral, globular to spherical	Spinose	Cancellate	A broad arch overhanging the umbilicus	7	Pearson et al. (2006)
Turborotalia ampliapertura	Moderately high trochospiral, compact globular	Spinose	Cancellate	Umbilical-extraumbilical high arch	7	Pearson et al. (2006)
Turborotalia cerroazulensis	Moderate trochospiral, rounded-conical shape	Spinose	Cancellate	Umbilical-extraumbilical broad arch sometimes slit-like	15	Pearson et al. (2006)
Turborotalia cocoaensis	Large, low to moderate trochospiral, compressed conical to slightly biconvex	Spinose	Cancellate	Umbilical-extraumbilical broad arch usually with an imperforate pustose lip	12	Pearson et al. (2006)
Turborotalia cunialensis	Low trochospiral, dorso-ventrally strongly compressed, biconvex	Spinose	Cancellate	Extraumbilical almost circular broad arch	12	Pearson et al. (2006)
Turborotalia euapertura	Trochospiral	Spinose	Cancellate	Umbilical large opening	7	Wade et al. (2007)
Turborotalia frontosa	Trochospiral	Spinose	Cancellate	Umbilical-extraumbilical broad high arch with pronounced imperforate lip	7	Pearson et al. (2006)
Turborotalia increbescens	Moderate to high trochospiral, compact and rounded	Spinose	Cancellate	Umbilical-extraumbilical very broad arch with an irregular imperforate lip	13	Pearson et al. (2006)
Turborotalia pomeroli	Large, high to moderate trochospiral	Spinose	Cancellate	Umbilical-extraumbilical irregular arch with an occasional imperforate lip	7	Pearson et al. (2006)
Turborotalia possagnoensis	Trochospiral, compressed	Spinose	Cancellate	Umbilical-extraumbilical broad arch usually with a thin imperforate lip	7	Pearson et al. (2006)
Turborotalita carcoselleensis	Low trochospiral, lobulate outline	Spinose	Cancellate	Umbilical wide arch bordered by an imperforate rim or narrow thickened lip	1	Olsson et al. (2006a)

Species name	General test architecture	Spinose / Non-spinose	Wall ultra-structure	Aperture type	Morpho-group	Morpho-group reference
Turborotalita clarkei	Small, slightly compressed trochospiral, final chamber distinctly spinose, can be heavily encrusted	Spinose	Cancellate	Interiomarginal umbilical-extraumbilical very low arch	1	Brummer & Kroon (1988)
Turborotalita cristata	Minute, very low trochospiral, equatorial periphery distinctly lobulate, short conical spine along periphery	Spinose	Cancellate	Interiomarginal umbilical-extraumbilical low arch bordered by thin lip	1	Kennett & Srinivasan (1983)
Turborotalita humilis	Minute, low trochospiral, equatorial periphery almost circular, tongue-like extension of the final chamber over the umbilicus	Spinose	Cancellate	Interiomarginal umbilical-extraumbilical except when covered by tongue-like extension. Several infralaminal apertures present	1	Kennett & Srinivasan (1983)
Turborotalita praequinqueloba	Very low trochospiral, lobulate outline, globular	Spinose	Cancellate	Umbilical wide arch bordered by an imperforate rim or narrow thickened lip	1	Olsson et al. (2006a)
Turborotalita quinqueloba	Small, slightly compressed, trochospiral, final chamber distinctly spinose	Spinose	Cancellate	An elongate slit often at the end of a flap-like structure of the final chamber	1	Kennett & Srinivasan (1983)

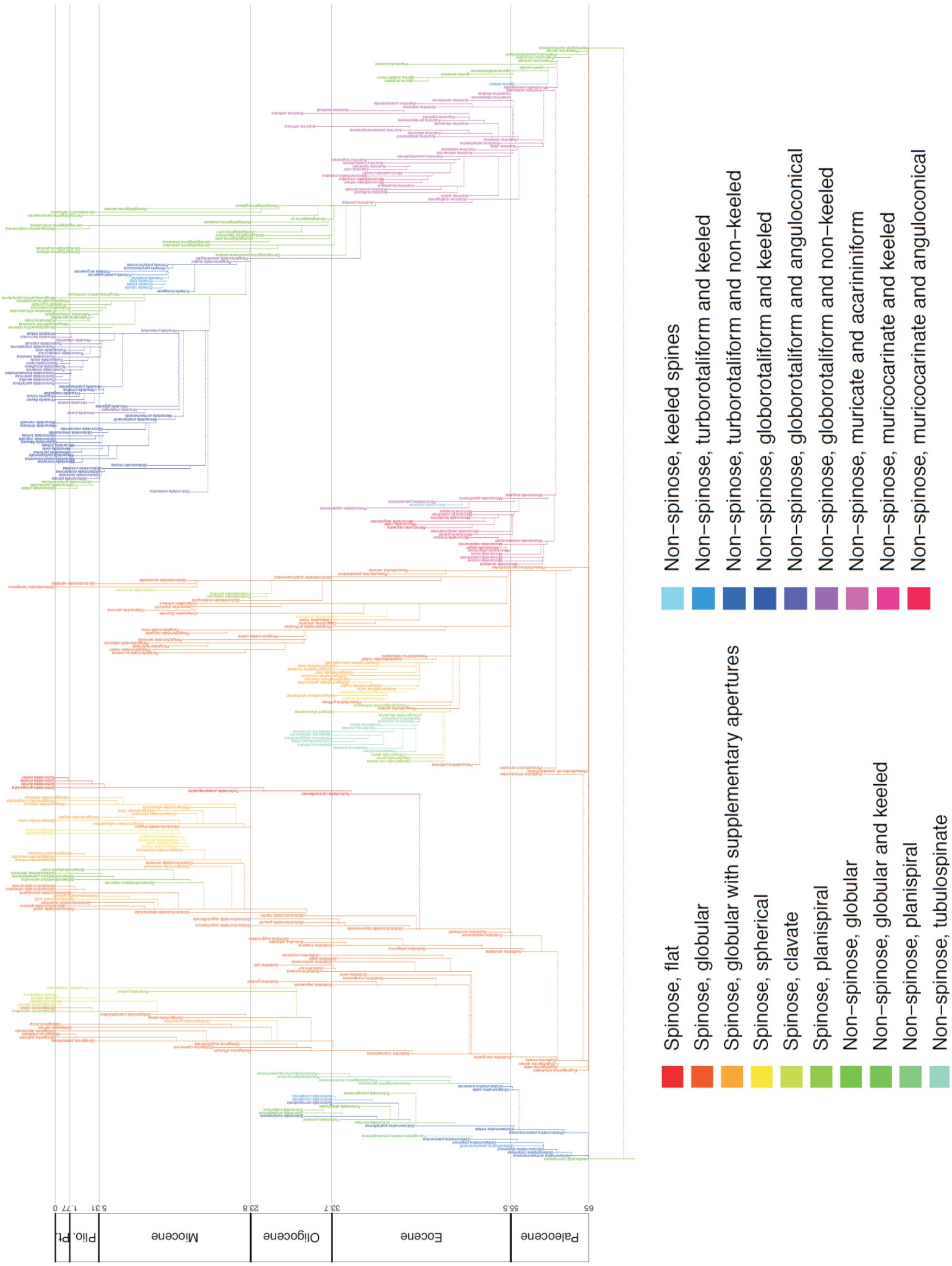


Figure 2.7 The morphospecies phylogeny with each species assigned to its respective morphogroup. A legible version of this figure is provided in the Electronic Appendix - Part A.

Morphospecies were also assigned to ecogroups, based on geochemical information from foraminiferal calcite and geographical information about environmental preference. Carbon ($\delta^{13}C$) and oxygen ($\delta^{18}O$) isotopic signatures of foraminiferal tests partly reflect the ambient water chemistry at the time of calcification and also biotic and kenetic fractionations of dissolved inorganic carbon from which the foraminifera construct their tests (see Hemleben *et al*., 1989 and Rohling & Cooke, 1999, for a review). The carbon isotope ratio varies with water mass and depth in the water column, with heavier ratios being found in surface waters where algal photosynthesis preferentially removes the light isotope, which is reintroduced at depth through respiration. Two major processes that overprint $\delta^{13}C$ in foraminiferal calcite have been taken into account when assigning the morphospecies and lineages to the distinct ecogroups. The first is photosymbiosis: the presence of algal symbionts around the foraminifera tends to increase the levels of the heavier carbon isotope, which is reflected in the foraminiferal calcite (Spero & Deniro, 1987). The second is the size of the test: small forms <150 μm are subject to a metabolically influenced microenvironment which results in relatively lighter carbon isotope values (Norris, 1996). The oxygen isotopic ratio reflects the isotopic ratio of sea water with a significant temperature-related fractionation. Foraminifera that live in warmer surface waters have lighter ($\delta^{18}O$) than those that calcify in colder deeper water. The combination of these isotopic signatures with geographic distributions permits species to be assigned to one of six ecogroups (Table 2.3, Fig. 2.8 and Electronic appendix, Part B).

Table 2.3 Ecogroup definitions, with associated chemical composition and/or geographical limit signatures.

Ecogroup	Isotopic Signature
Open ocean mixed-layer tropical/ subtropical, with symbionts	Very heavy $\delta^{13}C$ and relatively light $\delta^{18}O$
Open ocean mixed-layer tropical/ subtropical, without symbionts	$\delta^{13}C$ lighter than species with symbionts; also with relatively light $\delta^{18}O$
Open ocean thermocline	Light $\delta^{13}C$ and relatively heavy $\delta^{18}O$

Open ocean sub-thermocline	Very light $\delta^{13}C$ and very heavy $\delta^{18}O$
High latitude	Species that are only found in high latitude sites
Upwelling/high productivity	Species that are only found in sites of high productivity or upwelling

It is anticipated that morphogroup information will aid future research assessing the iterative nature of morphological characters within lineages and across the clade as a whole, and allow us to assess the extent and distribution of homoplasies within the phylogenies. Ecogroup information will also provide means to investigate how ecological niche space is occupied throughout the whole Cenozoic and during periods perturbed by significant environmental changes, such as the PETM and the transition into icehouse climates at the beginning of the Oligocene.

Table 2.4 A table containing information on the ecology, geographical and stratigraphical ranges of all Cenozoic macroperforate planktonic foraminifer species included in the phylogenies.

Species name	Eco-group	Eco-group reference	Geographic range	Geographic range reference	LAD	FAD	Date reference
Acarinina africana	1	This study	Low to middle latitudes	Berggren et al. (2006b)	55.3	55.4	Berggren et al. (2006b)
Acarinina alticonica	1	This study	Low to middle latitudes	Berggren et al. (2006b)	47	53.2	Berggren et al. (2006b)
Acarinina angulosa	1	This study	Low to middle latitudes	Berggren et al. (2006b)	46.4	55.7	Berggren et al. (2006b)
Acarinina aspensis	1	This study	Low latitudes	Berggren et al. (2006b)	48.7	50.4	Berggren et al. (2006b)
Acarinina boudreauxi	1	This study	Probably widespread currently only known from Indian Ocean	Berggren et al. (2006b)	43.7	49.8	Berggren et al. (2006b)
Acarinina bullbrooki	1	Boersma (1984); Pearson et al. (1993, 2001a)	Cosmopolitan	Berggren et al. (2006b)	40.5	49	Berggren et al. (2006b)
Acarinina coalingensis	1	Pearson et al. (1993, 2001a)	Cosmopolitan	Olsson et al. (1999)	50.1	56.5	Olsson et al. (1999)
Acarinina collactea	1	Pearson et al. (1993, 2001a)	Cosmopolitan	Berggren et al. (2006b)	30.3	50.45	Berggren et al. (2006b)

Species name	Eco-group	Eco-group reference	Geographic range	Geographic range reference	LAD	FAD	Date reference
Acarinina cuneicamerata	1	Boersma et al. (1987); Pearson et al. (2001a)	Equatorial Atlantic, Tethyan region and Indian Ocean	Berggren et al. (2006b)	44	50.8	Berggren et al. (2006b)
Acarinina echinata	1	This study	Low latitudes and southern middle to high latitudes	Berggren et al. (2006b)	31.8	43.2	Berggren et al. (2006b)
Acarinina esnaensis	1	This study	Low to high latitudes	Berggren et al. (2006b)	51.2	56.3	Berggren et al. (2006b)
Acarinina esnehensis	1	This study	Low to high latitudes	Berggren et al. (2006b)	50.4	55.8	Berggren et al. (2006b)
Acarinina interposita	1	This study	Tethys (Egypt) and in the northern Caucasus	Berggren et al. (2006b)	50.4	54	Berggren et al. (2006b)
Acarinina mcgowrani	1	Pearson et al. (1993); Wade & Kroon (2002) Wade (2004)	Low to middle latitudes	Berggren et al. (2006b)	38	49.25	Berggren et al. (2006b)
Acarinina mckannai	1	Shackleton et al. (1985)	Low latitudes	Olsson et al. (1999)	56.3	59.25	Olsson et al. (1999)
Acarinina medizzai	1	This study	Cosmopolitan	Berggren et al. (2006b)	35.8	42.5	Berggren et al. (2006b)
Acarinina nitida	1	D'hondt et al. (1994)	Low to high southern latitudes	Olsson et al. (1999)	56.2	59.5	Olsson et al. (1999)
Acarinina pentacamerata	1	This study	Cosmopolitan	Berggren et al. (2006b)	47	52.3	Berggren et al. (2006b)
Acarinina praetopilensis	1	Boersma et al. (1987) Pearson et al. (1993)	Low to middle latitudes	Berggren et al. (2006b)	40	48.7	Berggren et al. (2006b)
Acarinina primitiva	1	This study	Middle to high latitudes, less commonly in low latitudes	Berggren et al. (2006b)	38.8	50.8	Berggren et al. (2006b)
Acarinina pseudosubsphaerica	1	Pearson et al. (1993)	Low to middle latitudes	Berggren et al. (2006b)	42.3	50.4	Berggren et al. (2006b)
Acarinina pseudotopilensis	1	Boersma et al. (1987)	Low latitudes	Berggren et al. (2006b)	47.25	55.5	Berggren et al. (2006b)
Acarinina punctocarinata	1	This study	Cosmopolitan	Berggren et al. (2006b)	40.5	47	Berggren et al. (2006b)
Acarinina quetra	1	This study	Low latitudes	Berggren et al. (2006b)	50.4	54	Berggren et al. (2006b)
Acarinina rohri	1	This study	Low latitudes	Berggren et al. (2006b)	38.2	42.8	Berggren et al. (2006b)
Acarinina sibaiyaensis	1	Kelly et al. (1998)	Low latitudes	Berggren et al. (2006b)	55.3	55.45	Berggren et al. (2006b)
Acarinina soldadoensis	1	Pearson et al. (1993, 2001a)	Cosmopolitan	Olsson et al. (1999)	46.4	56.4	Olsson et al. (1999)

Species name	**Eco-group**	**Eco-group reference**	**Geographic range**	**Geographic range reference**	**LAD**	**FAD**	**Date reference**
Acarinina strabocella	1	This study	Northern middle latitudes to the Southern Ocean	Olsson et al. (1999)	59.3	60.8	Olsson et al. (1999)
Acarinina subsphaerica	1	This study	Cosmopolitan	Olsson et al. (1999)	54.2	59.4	Olsson et al. (1999)
Acarinina topilensis	1	Pearson et al. (1993, 2001a)	Low to middle latitudes	Berggren et al. (2006b)	40.3	43.2	Berggren et al. (2006b)
Acarinina wilcoxensis	1	This study	Low to high latitudes	Berggren et al. (2006b)	50.9	55.7	Berggren et al. (2006b)
Astrorotalia palmerae	1	This study	Low latitudes	Berggren et al. (2006a)	47.55	49.55	Berggren et al. (2006a)
Beella digitata	4	Coxall et al. (2007)	Low to middle latitudes	Kennett & Srinivasan (1983)	0	5	FAD: NEPTUNE; LAD: Kennett & Srinivasan (1983)
Beella megastoma	4	This study	Low to middle latitudes	Holmes (1984)	0.3	0	Bäckström et al. (2001)
Beella praedigitata	4	This study	Low to middle latitudes	Kennett & Srinivasan (1983)	0.8	12.4	Chaisson & Pearson (1997)
Catapsydrax africanus	4	Keller (1985)	Low to middle latitudes	Olsson et al. (2006c)	34.3	39	Olsson et al. (2006c)
Catapsydrax dissimilis	4	Keller (1985); Pearson et al. (1997b); Wade et al. (2007); Pearson & Wade (2009).	Low to middle latitudes	Kennett & Srinivasan (1983)	17.3	37.6	Kennett & Srinivasan (1983)
Catapsydrax globiformis	4	Keller (1985)	Low to middle latitudes	Olsson et al. (2006c)	34.3	40.4	Olsson et al. (2006c)
Catapsydrax howei	4	Keller (1985)	Low to middle latitudes	Olsson et al. (2006c)	33.7	44.35	Olsson et al. (2006c)
Catapsydrax parvulus	4	Keller (1985)	Low latitudes	Kennett & Srinivasan (1983)	10.9	17.1	Kennett & Srinivasan (1983)
Catapsydrax stainforthi	4	Keller (1985)	Low latitudes	Kennett & Srinivasan (1983)	16.9	27.5	NEPTUNE
Catapsydrax unicavus	4	Poore & Matthews (1984); Pearson et al. (2001a)	Cosmopolitan	Olsson et al. (2006c)	17.3	55	Olsson et al. (2006c)
Clavatorella bermudezi	4	Pearson & Shackleton (1995); Coxall et al. (2000)	Low latitudes	Kennett & Srinivasan (1983)	12.1	16.4	Kennett & Srinivasan (1983)
Clavigerinella akersi	4	Coxall et al. (2000, 2007)	Low to middle latitudes	Coxall & Pearson (2006)	42.7	47.22	Coxall & Pearson (2006)

Species name	**Eco-group**	**Eco-group reference**	**Geographic range**	**Geographic range reference**	**LAD**	**FAD**	**Date reference**
Clavigerinella caucasica	4	This study	Known only from Austria and Tanzania	Coxall & Pearson (2006)	44.45	44.6	Coxall & Pearson (2006)
Clavigerinella colombiana	4	Coxall et al. (2000)	Cosmopolitan on continental shelf settings	Coxall & Pearson (2006)	43.3	47.4	Coxall & Pearson (2006)
Clavigerinella eocanica	4	Pearson et al. (1993); Coxall et al. (2000)	Low to middle latitudes	Coxall & Pearson (2006)	34	48.1	Coxall & Pearson (2006)
Clavigerinella jarvisi	4	Coxall et al. (2000)	Low to middle latitudes	Coxall & Pearson (2006)	43.3	47.25	Coxall & Pearson (2006)
Cribrohantkenina inflata	2	Wade & Pearson (2008)	Low to middle latitudes	Coxall & Pearson (2006)	33.7	36.4	Coxall & Pearson (2006)
Dentoglobigerina altispira	1	Pearson et al. (2001b)	Low latitudes	Kennett & Srinivasan (1983)	3	23.7	FAD: B.S. Wade & P. N. Pearson in preparation ; LAD: Spezzaferri (1994)
Dentoglobigerina baroemoensis	3	D. R. M. Stewart unpublished data	Low latitudes	Kennett & Srinivasan (1983)	3.3	32	FAD: B.S. Wade & P. N. Pearson in prep.; LAD: Chaisson & Pearson (1997)
Dentoglobigerina binaiensis	4	Pearson & Shackleton (1995)	Low latitudes	Kennett & Srinivasan (1983)	18.8	26	FAD: B.S. Wade & P. N. Pearson in preparation ; LAD: Kennett & Srinivasan (1983)
Dentoglobigerina galavisi	3	Wade & Pearson (2008)	Low to middle latitudes	Olsson et al. (2006b)	27.2	39	FAD: Olsson et al. (2006b); LAD: B.S. Wade & P. N. Pearson in preparation
Dentoglobigerina globosa	3	D. R. M. Stewart unpublished data	Low latitudes	Kennett & Srinivasan (1983)	3	27.1	FAD: B.S. Wade & P. N. Pearson in preparation ; LAD: Kennett & Srinivasan (1983)
Dentoglobigerina globularis	3	Pearson et al. (1997b); Wade et al. (2007); Wade & Pearson (2008)	Low to middle latitudes	Spezzaferri (1994)	18.8	34	FAD: B.S. Wade & P. N. Pearson in preparation ; LAD: Spezzaferri (1994)

Species name	Eco-group	Eco-group reference	Geographic range	Geographic range reference	LAD	FAD	Date reference
Dentoglobigerina larmeui	3	Pearson & Wade (2009); Pearson et al. (1997b)	Cosmopolitan	Spezzaferri (1994)	11.2	27.3	FAD: B.S. Wade & P. N. Pearson in preparation ; LAD: Spezzaferri (1994)
Dentoglobigerina prasaepis	4	D. R. M. Stewart unpublished data	Cosmopolitan	Spezzaferri (1994)	23.8	33.3	FAD: Olsson et al. (2006b); LAD: B.S. Wade & P. N. Pearson in preparation
Dentoglobigerina pseudovenezuelana	3	Wade & Pearson (2008)	Low latitudes	Olsson et al. (2006b)	27.4	35.4	Kennett & Srinivasan (1983)
Dentoglobigerina rohri	4	Pearson & Wade (2009); Poore & Matthews (1984)	Cosmopolitan	Spezzaferri (1994)	24.3	30	Spezzaferri (1994)
Dentoglobigerina sellii	4	Van Eijden & Ganssen (1995)	Low to middle latitudes	Spezzaferri (1994)	24.1	33.4	B.S. Wade & P. N. Pearson in preparation
Dentoglobigerina sp	3	This study			32.9	33.9	Spezzaferri (1994)
Dentoglobigerina tapuriensis	4	D. R. M. Stewart unpub. data	Cosmopolitan	Spezzaferri (1994)	25.5	33.7	B.S. Wade & P. N. Pearson in preparation
Dentoglobigerina venezuelana	4	Gasperi & Kennett (1993); Pearson & Shackleton (1995); Pearson et al. (2001b); Wade et al. (2007); Wade & Pearson (2008); Coxall et al. (2007); Pearson & Wade (2009)	Low latitudes	Kennett & Srinivasan (1983)	3.3	33.2	FAD: B.S. Wade & P. N. Pearson in preparation ; LAD: Chaisson & Pearson (1997)
Eoglobigerina edita	3	This study	Cosmopolitan	Olsson et al. (1999)	61.15	64.9	Olsson et al. (1999)
Eoglobigerina eobulloides	3	Berggren & Norris (1997); D'hondt & Zachos (1993)	Cosmopolitan	Olsson et al. (1999)	63.6	64.97	Olsson et al. (1999)
Eoglobigerina spiralis	3	This study	Cosmopolitan	Olsson et al. (1999)	60.9	61.2	Olsson et al. (1999)

Species name	Eco-group	Eco-group reference	Geographic range	Geographic range reference	LAD	FAD	Date reference
Fohsella birnageae	3	Keller (1985); Hodell & Vayavananda (1993)	Low latitudes	Kennett & Srinivasan (1983)	16.4	17	Norris et al. (1993)
Fohsella fohsi	3	Keller (1985); Hodell & Vayavananda (1993); Pearson & Shackleton (1995)	Low latitudes	Kennett & Srinivasan (1983)	11.9	13.4	Kennett & Srinivasan (1983)
Fohsella lenguaensis	3	Keller (1985); Hodell & Vayavananda (1993)	Low latitudes	Kennett & Srinivasan (1983)	6.7	13.7	Norris et al. (1993)
Fohsella lobata	3	Keller (1985); Hodell & Vayavananda (1993); Pearson & Shackleton (1995)	Low latitudes	Kennett & Srinivasan (1983)	11.9	13.3	Kennett & Srinivasan (1983)
Fohsella paralenguaensis	3	Keller (1985); Hodell & Vayavananda (1993)	Low latitudes	Kennett & Srinivasan (1983)	9.3	13.6	Kennett & Srinivasan (1983)
Fohsella peripheroacuta	3	Keller (1985); Hodell & Vayavananda (1993); Pearson & Shackleton (1995)	Low latitudes	Kennett & Srinivasan (1983)	13.4	14.3	Kennett & Srinivasan (1983)
Fohsella peripheroronda	3	Keller (1985); Hodell & Vayavananda (1993); Pearson et al. (2001b); Coxall et al. (2007)	Low latitudes	Kennett & Srinivasan (1983)	13.8	22	Norris et al. (1993)
Fohsella praefohsi	3	Keller (1985); Hodell & Vayavananda (1993); Pearson & Shackleton (1995)	Low latitudes	Kennett & Srinivasan (1983)	13.1	13.8	Norris et al. (1993)
Fohsella robusta	3	Keller (1985); Hodell & Vayavananda (1993)	Low latitudes	Kennett & Srinivasan (1983)	11.9	13.1	Kennett & Srinivasan (1983)

Species name	Eco-group	Eco-group reference	Geographic range	Geographic range reference	LAD	FAD	Date reference
Globanomalina archeocompressa	3	This study	Western equatorial pacific, Gulf of Mexico, south Atlantic Ocean	Olsson et al. (1999)	62.8	64.95	Olsson et al. (1999)
Globanomalina australiformis	3	This study	Southern middle to high latitudes	Olsson et al. (1999)	43.8	55.88	Olsson et al. (1999)
Globanomalina chapmani	3	Olsson et al. (1999)	Cosmopolitan in middle to high latitudes	Olsson et al. (1999)	53.7	59.45	Olsson et al. (1999)
Globanomalina compressa	3	Olsson et al. (1999)	Cosmopolitan	Olsson et al. (1999)	60.7	62.9	Olsson et al. (1999)
Globanomalina ehrenbergi	3	This study	Cosmopolitan in low to middle latitudes	Olsson et al. (1999)	59.38	61.1	Olsson et al. (1999)
Globanomalina imitata	3	This study	Northern Caucasus, S.E. India, Atlantic and Gulf of Mexico coastal plains	Olsson et al. (1999)	55.8	62.05	Olsson et al. (1999)
Globanomalina luxorensis	2	Olsson & Hemleben (2006)	Low to middle latitudes	Olsson & Hemleben (2006)	54.45	55.7	Olsson et al. (1999)
Globanomalina ovalis	2	This study	Northern and southern middle latitudes	Olsson et al. (1999)	55.3	56.5	Olsson et al. (1999)
Globanomalina planocompressa	3	Olsson et al. (1999)	Northern hemisphere and middle to low latitudes	Olsson et al. (1999)	62	64.9	Olsson et al. (1999)
Globanomalina planoconica	3	This study	Low to middle latitudes	Olsson et al. (1999)	50.6	56.3	Olsson et al. (1999)
Globanomalina pseudomenardii	3	Olsson et al. (1999)	Low to middle latitudes	Olsson et al. (1999)	55.9	59.4	Olsson et al. (1999)
Globigerina angulisuturalis	1	Poore & Matthews (1984)	Low to middle latitudes	Kennett & Srinivasan (1983)	22.5	29.4	FAD: Pearson (1998); LAD: Spezzaferri (1994)
Globigerina bulloides	2	Vergnaud-Grazzini (1976); Durazzi (1981).	Middle latitudes, rare in low latitudes	Kennett & Srinivasan (1983)	0	14.8	Kennett & Srinivasan (1983)
Globigerina ciperoensis	2	D. R. M. Stewart unpublished data	Low to middle latitudes	Kennett & Srinivasan (1983)	19.3	31.2	FAD: Pearson (1998); LAD: Kennett & Srinivasan (1983)
Globigerina druryi	1	This study	Low latitudes	Kennett & Srinivasan (1983)	0.6	21.5	Kennett & Srinivasan (1983)

Species name	Eco-group	Eco-group reference	Geographic range	Geographic range reference	LAD	FAD	Date reference
Globigerina eamesi	1	This study	Middle latitudesrare in low latitudes	Kennett & Srinivasan (1983)	2	26.3	Kennett & Srinivasan (1983)
Globigerina falconensis	1	This study	High latitudes	Kennett & Srinivasan (1983)	0	18.4	Olsson et al. (2006a)
Globigerina officinalis	1	Pearson et al. (2001a)	Low to middle latitudes	Olsson et al. (2006a)	23.8	43.5	FAD: Olsson et al. (2006a); LAD: Pearson (1998)
Globigerina praebulloides	1	Pearson et al. (1997b)	Low to middle latitudes	Kennett & Srinivasan (1983)	4.8	33.8	FAD: Pearson (1998); LAD: Stanley et al. (1988)
Globigerina umbilicata	1	This study	Low latitudes	Kennett & Srinivasan (1983)	0.6	2.5	Kennett & Srinivasan (1983)
Globigerinatheka barri	1	This study	Low to middle latitudes	Premoli Silva et al. (2006)	36.3	44	Premoli Silva et al. (2006)
Globigerinatheka curryi	1	This study	Low to middle latitudes	Premoli Silva et al. (2006)	41.6	44.41	Premoli Silva et al. (2006)
Globigerinatheka euganea	1	This study	Low to middle latitudes	Premoli Silva et al. (2006)	40.2	42.8	Premoli Silva et al. (2006)
Globigerinatheka index	1	Boersma et al. (1979); Pearson et al. (2001a); Pearson & Palmer (1999)	Cosmopolitan	Premoli Silva et al. (2006)	34.3	43.8	Premoli Silva et al. (2006)
Globigerinatheka korotkovi	1	This study	Low to middle latitudes	Premoli Silva et al. (2006)	35.5	44.3	Premoli Silva et al. (2006)
Globigerinatheka kugleri	1	Boersma et al. (1987); Pearson & Palmer (1999)	Low to middle latitudes	Premoli Silva et al. (2006)	39.8	43.95	Premoli Silva et al. (2006)
Globigerinatheka luterbacheri	1	This study	Middle latitudes	Premoli Silva et al. (2006)	34.3	40.3	Premoli Silva et al. (2006)
Globigerinatheka mexicana	1	Boersma et al. (1987); Wade (2004)	Low to middle latitudes	Premoli Silva et al. (2006)	36	44.4	Premoli Silva et al. (2006)
Globigerinatheka semiinvoluta	1	Poore & Matthews (1984); Pearson et al. (2001a); Wade & Kroon (2002)	Low to middle latitudes	Premoli Silva et al. (2006)	35.8	38.5	Premoli Silva et al. (2006)
Globigerinatheka subconglobata	1	Pearson et al. (1993)	Cosmopolitan	Premoli Silva et al. (2006)	39.6	45.95	Premoli Silva et al. (2006)
Globigerinatheka tropicalis	1	This study	Low to middle latitudes	Premoli Silva et al. (2006)	33.8	39.1	Premoli Silva et al. (2006)
Globigerinella adamsi	4	Coxall et al. (2007)		Coxall et al. (2007)	0	0.7	Coxall et al. (2007)

Species name	**Eco-group**	**Eco-group reference**	**Geographic range**	**Geographic range reference**	**LAD**	**FAD**	**Date reference**
Globigerinella calida	3	This study	Low latitudes	Kennett & Srinivasan (1983)	0	4.4	Chaisson & Pearson (1997)
Globigerinella obesa	3	D. R. M. Stewart unpublished data	Low to middle latitudes	Kennett & Srinivasan (1983)	15.6	31.2	FAD: Pearson (1998); LAD: Kennett & Srinivasan (1983)
Globigerinella praesiphonifera	3	Pearson et al. (2001b); Pearson & Shackleton (1995)	Low latitudes	Kennett & Srinivasan (1983)	11.7	23.2	Kennett & Srinivasan (1983)
Globigerinella siphonifera	3	Vergnaud-Grazzini (1976)	Low to middle latitudes	Kennett & Srinivasan (1983)	0	12.5	FAD: Kennett & Srinivasan (1983); LAD: Chaisson & Pearson (1997)
Globigerinoides altiapertura	1	Keller (1985)	Low latitudes	Kennett & Srinivasan (1983)	16.4	22	Stanley et al. (1988)
Globigerinoides bisphericus	1	Keller (1985); Pearson & Shackleton (1995)	Low latitudes	Pearson et al. (1997a)	15.6	18.2	Pearson & Chaisson (1997)
Globigerinoides conglobatus	1	Keller (1985)	Low latitudes	Kennett & Srinivasan (1983)	0	7.5	Kennett & Srinivasan (1983)
Globigerinoides diminutus	1	Keller (1985)	Low latitudes	Kennett & Srinivasan (1983)	14.8	17.3	Stanley et al. (1988)
Globigerinoides extremus	1	Keller (1985)	Low latitudes	Kennett & Srinivasan (1983)	1.6	8.3	Kennett & Srinivasan (1983)
Globigerinoides fistulosus	1	Keller (1985); Pearson & Shackleton (1995)	Low latitudes	Kennett & Srinivasan (1983)	2	3.6	Chaisson & Pearson (1997)
Globigerinoides mitra	1	Keller (1985); Pearson et al. (2001b)	Low latitudes	Kennett & Srinivasan (1983)	12.1	18	Stanley et al. (1988)
Globigerinoides obliquus	1	Keller (1985); Pearson et al. (2001b)	Low latitudes	Kennett & Srinivasan (1983)	1.3	21.95	FAD: Chaisson & Leckie (1993); LAD: Chaisson & Pearson (1997)
Globigerinoides parawoodi	1	Keller (1985)	Middle latitudes	Kennett & Srinivasan (1983)	16.4	21.5	Kennett & Srinivasan (1983)

Species name	Eco-group	Eco-group reference	Geographic range	Geographic range reference	LAD	FAD	Date reference
Globigerinoides primordius	1	Keller (1985); Pearson & Wade (2009); Pearson et al. (1997b); Poore & Matthews (1984)	Low latitudes	Kennett & Srinivasan (1983)	18.8	27	FAD: Spezzaferri (1994); LAD: Chaproniere (1992)
Globigerinoides ruber	1	Keller (1985); Pearson et al. (2001b); Pearson & Shackleton (1995)	Low latitudes	Kennett & Srinivasan (1983)	0	15.1	Stanley et al. (1988)
Globigerinoides sacculifer	1	Keller (1985); D. R. M. Stewart unpublished data	Low latitudes	Kennett & Srinivasan (1983)	0	10.9	Chaisson & Pearson (1997)
Globigerinoides seigliei	1	Keller (1985)	Low latitudes	Kennett & Srinivasan (1983)	5.3	9.6	Stanley et al. (1988)
Globigerinoides subquadratus	1	Keller (1985)	Low latitudes	Kennett & Srinivasan (1983)	10.8	23	Kennett & Srinivasan (1983)
Globigerinoides trilobus	1	Keller (1985); Pearson et al. (2001b); Pearson & Shackleton (1995)	Low latitudes	Kennett & Srinivasan (1983)	0	22.6	FAD: Stanley et al. (1988); LAD: Chaisson & Pearson (1997)
Globoconella conoidea	3	Schneider & Kennett (1996)	Low to middle latitudes	Kennett & Srinivasan (1983)	5.7	16.4	Wei (1994)
Globoconella conomiozea	3	Schneider & Kennett (1996)	Low to middle latitudes	Kennett & Srinivasan (1983)	5.5	6	Wei (1994)
Globoconella inflata	3	Vergnaud-Grazzini (1976)	Low to high latitudes	Kennett & Srinivasan (1983)	0	2.6	Wei (1994)
Globoconella miozea	3	Schneider & Kennett (1996)	Low to middle latitudes	Kennett & Srinivasan (1983)	11.2	18.3	D. R. M. Stewart unpublished data
Globoconella pliozea	3	Schneider & Kennett (1996)		Wei (1994)	3.9	5.35	Wei (1994)
Globoconella puncticulata	3	Schneider & Kennett (1996)	Low to middle latitudes	Kennett & Srinivasan (1983)	2.3	4.6	Wei (1994)
Globoconella sphericomiozea	3	Schneider & Kennett (1996)	Middle latitudes	Kennett & Srinivasan (1983)	4.5	5.4	Wei (1994)

Species name	Eco-group	Eco-group reference	Geographic range	Geographic range reference	LAD	FAD	Date reference
Globoconella terminalis	3	Schneider & Kennett (1996)		Wei (1987)	5.3	5.6	Wei (1994)
Globoquadrina conglomerata	3	This study	Low latitudes	Bė (1968)	0	4.2	
Globoquadrina dehiscens	3	Pearson & Shackleton (1995); Keller (1985)	Low to middle latitudes	Kennett & Srinivasan (1983)	4.8	25.1	B.S. Wade & P. N. Pearson in preparation
Globorotalia flexuosa	3	D. R. M. Stewart unpublished data	Low latitudes	Kennett & Srinivasan (1983)	0.2	5.7	D. R. M. Stewart unpublished data
Globorotalia merotumida	3	This study	Low latitudes	Kennett & Srinivasan (1983)	5.8	11	D. R. M. Stewart unpublished data
Globorotalia plesiotumida	3	Pearson & Shackleton (1995)	Low latitudes	Kennett & Srinivasan (1983)	4.5	6.4	D. R. M. Stewart unpublished data
Globorotalia tumida	3	Pearson & Shackleton (1995); D. R. M. Stewart unpublished data	Low latitudes	Kennett & Srinivasan (1983)	0	5.8	D. R. M. Stewart unpublished data
Globorotalia ungulata	3	This study	Low latitudes	Kennett & Srinivasan (1983)	0	4.9	FAD: Chaisson & Leckie (1993); LAD: D. R. M. Stewart unpublished data
Globorotalia zealandica	3	This study	Low latitudes	Kennett & Srinivasan (1983)	16.4	18.6	D. R. M. Stewart unpublished data
Globorotaloides eovariabilis	4	Keller (1985)	Southern and Northern high latitudes	Olsson et al. (2006c)	16	47	Olsson et al. (2006c)
Globorotaloides hexagonus	4	Keller (1985); Pearson et al. (2001b)	Low latitudes	Kennett & Srinivasan (1983)	0	17.3	Kennett & Srinivasan (1983)
Globorotaloides quadrocameratus	4	Keller (1985)	Low to high latitudes	Olsson et al. (2006c)	33.7	55.2	Olsson et al. (2006c)
Globorotaloides testarugosa	4	Keller (1985)	Middle latitudes	Spezzaferri (1994)	22.5	32.5	Spezzaferri (1994)
Globorotaloides variabilis	4	Keller (1985)	Low latitudes	Kennett & Srinivasan (1983)	4.8	17.1	Kennett & Srinivasan (1983)
Globoturborotalita anguliofficinalis	2	Douglas & Savin (1978)	Low to middle latitudes	Olsson et al. (2006a)	23.8	34.5	Olsson et al. (2006a)
Globoturborotalita apertura	2	This study	Low to middle latitudes	Kennett & Srinivasan (1983)	1.3	10.9	Stanley et al. (1988)

Species name	Eco-group	Eco-group reference	Geographic range	Geographic range reference	LAD	FAD	Date reference
Globoturborotalita bassriverensis	2	Pearson et al. (2001a)	Low to middle latitudes	Olsson et al. (2006a)	42.4	55.4	Olsson et al. (2006a)
Globoturborotalita bollii	1	Keller (1985)	Low latitudes	Kennett & Srinivasan (1983)	2.3	12.5	Stanley et al. (1988)
Globoturborotalita brazieri	1	This study	Low to middle latitudes	Kennett & Srinivasan (1983)	15.1	23.8	Kennett & Srinivasan (1983)
Globoturborotalita connecta	1	This study	Low to middle latitudes	Kennett & Srinivasan (1983)	16.8	23	Stanley et al. (1988)
Globoturborotalita decoraperta	2	This study	Low latitudes	Kennett & Srinivasan (1983)	2	15	FAD: Stanley et al. (1988); LAD: Chaisson & Pearson (1997)
Globoturborotalita gnaucki	2	This study	Low to middle latitudes	Olsson et al. (2006a)	30.3	35.3	Olsson et al. (2006a)
Globoturborotalita kennetti	1	Keller (1985)	Low latitudes	Kennett & Srinivasan (1983)	5.3	9	Stanley et al. (1988)
Globoturborotalita labiacrassata	2	This study	South Atlantic and Pacific	Spezzaferri (1994)	16.3	30.4	Spezzaferri (1994)
Globoturborotalita martini	1	Pearson et al. (2001a)	Low to middle latitudes	Olsson et al. (2006a)	30.3	44	FAD: Olsson et al. (2006a); LAD: NEPTUNE
Globoturborotalita nepenthes	2	D. R. M. Stewart unpublished data	Low latitudes	Kennett & Srinivasan (1983)	4.3	12.1	Stanley et al. (1988)
Globoturborotalita ouachitaensis	1	Wade & Pearson (2008)	Low to middle latitudes	Olsson et al. (2006a)	23.8	43.1	Olsson et al. (2006a)
Globoturborotalita rubescens	2	This study	Low latitudes	Kennett & Srinivasan (1983)	0	3.6	FAD: Chassion & Pearson (1997); LAD: Stanley et al. (1988)
Globoturborotalita tenella	2	This study	Low latitudes	Kennett & Srinivasan (1983)	0	2.4	Kennett & Srinivasan (1983)
Globoturborotalita woodi	1	Pearson et al. (1997b, 2007)	Low to middle latitudes	Kennett & Srinivasan (1983)	2.4	30.6	FAD: Stanley et al. (1988); LAD: Chaisson & Pearson (1997)
Guembelitrioides nuttalli	3	Pearson et al. (1993)	Low to middle latitudes	Olsson et al. (2006c)	42.3	46.4	Olsson et al. (2006c)

Species name	Eco-group	Eco-group reference	Geographic range	Geographic range reference	LAD	FAD	Date reference
Hantkenina alabamensis	2	Poore & Matthews (1984); Boersma et al. (1987) Coxall et al. (2000); Pearson et al. (2001a); Wade & Kroon (2002)	Low to middle latitudes	Coxall & Pearson (2006)	33.7	39.8	Coxall & Pearson (2006)
Hantkenina australis	3	This study	Low to middle latitudes and commonly in high northerly and southerly extremes	Coxall & Pearson (2006)	38.1	42.3	Coxall & Pearson (2006)
Hantkenina compressa	2	Coxall & Pearson (2006)	Low to middle latitudes	Coxall & Pearson (2006)	33.7	41.2	Coxall & Pearson (2006)
Hantkenina dumblei	3	Pearson et al. (1993, 2001a); Coxall & Pearson (2006)	Low to middle latitudes	Coxall & Pearson (2006)	39	43.9	Coxall & Pearson (2006)
Hantkenina lehneri	3	This study	Found in TrinidadTanzania and Russia	Coxall & Pearson (2006)	41.4	43.91	Coxall & Pearson (2006)
Hantkenina liebusi	4	Pearson et al. (1993, 2001a); Coxall et al. (2000)	Low to middle latitudes	Coxall & Pearson (2006)	39.7	44.2	Coxall & Pearson (2006)
Hantkenina mexicana	4	Coxall et al. (2000); Pearson et al. (2001a)	Low latitudes	Coxall & Pearson (2006)	43.8	44.41	Coxall & Pearson (2006)
Hantkenina nanggulanensis	2	Wade & Pearson (2008)	Low to middle latitudes	Coxall & Pearson (2006)	33.7	38.1	Coxall & Pearson (2006)
Hantkenina primitiva	3	This study	Cosmopolitan, most common in shelf environments	Coxall & Pearson (2006)	33.7	40	Coxall & Pearson (2006)
Hantkenina singanoae	3	This study	Found only in Tanzania and Austria so far	Coxall & Pearson (2006)	44.4	44.5	Coxall & Pearson (2006)
Hedbergella holmdelensis	3	This study	Cosmopolitan	Olsson et al. (1999)	64.9	70.6	Olsson et al. (1999)
Hedbergella monmouthensis	3	Berggren & Norris (1997)	Cosmopolitan	Olsson et al. (1999)	64.85	69.2	Olsson et al. (1999)
Hirsutella bermudezi	4	This study	Low to middle latitudes	Kennett & Srinivasan (1983)	0	2	D. R. M. Stewart unpublished data

Species name	Eco-group	Eco-group reference	Geographic range	Geographic range reference	LAD	FAD	Date reference
Hirsutella challengeri	4	This study	Middle latitudes	Kennett & Srinivasan (1983)	10	15.15	D. R. M. Stewart unpublished data
Hirsutella cibaoensis	4	This study	Low to middle latitudes	Kennett & Srinivasan (1983)	4.4	7.2	D. R. M. Stewart unpublished data
Hirsutella evoluta	4	This study	Low to middle latitudes	This study	3.9	4.8	D. R. M. Stewart unpublished data
Hirsutella gigantea	4	This study	Low to middle latitudes	D. R. M. Stewart unpublished data	14.99	8.8	D. R. M. Stewart unpublished data
Hirsutella hirsuta	4	This study	Low to middle latitudes	Kennett & Srinivasan (1983)	0	3	D. R. M. Stewart unpublished data
Hirsutella juanai	4	This study	Low to middle latitudes	Kennett & Srinivasan (1983)	4.8	10.9	D. R. M. Stewart unpublished data
Hirsutella margaritae	4	This study	Low to middle latitudes	Kennett & Srinivasan (1983)	2.95	5.89	D. R. M. Stewart unpublished data
Hirsutella praemargaritae	4	This study	Low to middle latitudes	This study	5.7	8.2	D. R. M. Stewart unpublished data
Hirsutella praescitula	4	Pearson et al. (2001b)	Low to middle latitudes	Kennett & Srinivasan (1983)	14.8	18.3	D. R. M. Stewart unpublished data
Hirsutella primitiva	4	This study	Low to middle latitudes	This study	4.8	5.9	D. R. M. Stewart unpublished data
Hirsutella scitula	4	Shackleton & Vincent (1978); D. R. M. Stewart unpublished data	Low to middle latitudes	Kennett & Srinivasan (1983)	0	15	D. R. M. Stewart unpublished data
Hirsutella theyeri	4	This study	Low latitudes	Kennett & Srinivasan (1983)	0	3.5	D. R. M. Stewart unpublished data
Igorina albeari	1	Berggren & Norris (1997)	Tropical to sub-tropical	Olsson et al. (1999)	55.9	60.05	Olsson et al. (1999)
Igorina anapetes	1	This study	Low to middle latitudes	Berggren et al. (2006a)	43.6	45.4	Berggren et al. (2006a)
Igorina broedermanni	1	Pearson et al. (1993, 2001a)	Low to middle latitudes	Berggren et al. (2006a)	43.7	55.6	Berggren et al. (2006a)
Igorina lodoensis	1	This study	Low to middle latitudes	Berggren et al. (2006a)	50.5	55.8	Berggren et al. (2006a)
Igorina pusilla	1	This study	Low to middle latitudes	Olsson et al. (1999)	59.5	60.95	Olsson et al. (1999)

Species name	**Eco-group**	**Eco-group reference**	**Geographic range**	**Geographic range reference**	**LAD**	**FAD**	**Date reference**
Igorina tadjikistanensis	1	Berggren & Norris (1997)	Low to middle latitudes	Olsson et al. (1999)	55.4	60	Olsson et al. (1999)
Menardella archeomenardii	3	Pearson & Shackleton (1995); D. R. M. Stewart unpublished data	Low latitudes	Kennett & Srinivasan (1983)	14.2	15.6	D. R. M. Stewart unpublished data
Menardella exilis	3	This study	Low latitudes	Kennett & Srinivasan (1983)	1.9	5.7	D. R. M. Stewart unpublished data
Menardella fimbriata	3	This study	Low latitudes	Kennett & Srinivasan (1983)	0	0.2	D. R. M. Stewart unpublished data
Menardella limbata	3	This study	Low latitudes	Kennett & Srinivasan (1983)	2.3	11.4	D. R. M. Stewart unpublished data
Menardella menardii	3	Shackleton & Vincent (1978); Pearson & Shackleton (1995); D. R. M. Stewart unpublished data	Low latitudes	Kennett & Srinivasan (1983)	0	12.31	D. R. M. Stewart unpublished data
Menardella miocenica	3	This study	Low latitudes	Kennett & Srinivasan (1983)	2.4	3.3	FAD: Chassion & Pearson (1997); LAD: D. R. M. Stewart unpublished data
Menardella multicamerata	3	D. R. M. Stewart unpublished data	Low latitudes	Kennett & Srinivasan (1983)	2.2	6.5	D. R. M. Stewart unpublished data
Menardella pertenius	3	This study	Low latitudes	Kennett & Srinivasan (1983)	1.7	3.2	FAD: Chassion & Pearson (1997); LAD: D. R. M. Stewart unpublished data
Menardella praemenardii	3	Pearson & Shackleton (1995); D. R. M. Stewart unpublished data	Low latitudes	Kennett & Srinivasan (1983)	12.3	14.6	FAD: Chassion & Pearson (1997); LAD: D. R. M. Stewart unpublished data

Species name	Eco-group	Eco-group reference	Geographic range	Geographic range reference	LAD	FAD	Date reference
Menardella pseudomiocenica	3	D. R. M. Stewart unpublished data	Low latitudes	Kennett & Srinivasan (1983)	2.4	7.5	FAD: Chassion & Leckie (1993); LAD: D. R. M. Stewart unpublished data
Morozovella acuta	1	Shackleton et al. (1985)	Low to middle latitudes	Olsson et al. (1999)	54.45	59.15	Olsson et al. (1999)
Morozovella acutispira	1	Berggren & Norris (1997)	Low to middle latitudes	Olsson et al. (1999)	56.35	59.4	Olsson et al. (1999)
Morozovella aequa	1	Lu & Keller (1996); Berggren & Norris (1997)	Cosmopolitan	Olsson et al. (1999)	50.8	56.5	Olsson et al. (1999)
Morozovella allisonensis	1	Kelly et al. (1998)	Low latitudes	Berggren & Pearson (2006)	55.3	55.5	Berggren & Pearson (2006)
Morozovella angulata	1	Douglas & Savin (1978); Boersma & Premoli Silva (1983); Shackleton et al. (1985)	Low to middle latitudes	Olsson et al. (1999)	59.3	60.95	Olsson et al. (1999)
Morozovella apanthesma	1	Lu & Keller (1996); Berggren & Norris (1997)	Northern middle latitudes to the Southern Ocean	Olsson et al. (1999)	54.45	60	Olsson et al. (1999)
Morozovella aragonensis	1	Boersma et al. (1987); Pearson et al. (1993, 2001a)	Low latitudes	Berggren & Pearson (2006)	43.6	52.3	Berggren & Pearson (2006)
Morozovella caucasica	1	This study	Low latitudes	Berggren & Pearson (2006)	45.15	50.8	FAD: Berggren & Pearson (2006); LAD: NEPTUNE
Morozovella conicotruncata	1	Boersma & Premoli Silva (1983); Berggren & Norris (1997)	Low latitudes	Olsson et al. (1999)	59.3	60.8	Olsson et al. (1999)
Morozovella crater	1	This study	Low latitudes	Berggren & Pearson (2006)	43.9	53.5	Berggren & Pearson (2006)
Morozovella edgari	1	Kelly et al. (2001)	Low latitudes	Berggren & Pearson (2006)	54	54.9	Berggren & Pearson (2006)
Morozovella formosa	1	This study	Low latitudes	Berggren & Pearson (2006)	50.4	54	Berggren & Pearson (2006)
Morozovella gracilis	1	This study	Cosmopolitan	Olsson et al. (1999)	50.8	55.7	Olsson et al. (1999)
Morozovella lensiformis	1	Boersma et al. (1987)	Low latitudes	Berggren & Pearson (2006)	50.6	54	Berggren & Pearson (2006)
Morozovella marginodentata	1	This study	Low latitudes	Berggren & Pearson (2006)	51.6	55.55	Berggren & Pearson (2006)

Species name	**Eco-group**	**Eco-group reference**	**Geographic range**	**Geographic range reference**	**LAD**	**FAD**	**Date reference**
Morozovella occlusa	1	Shackleton et al. (1985); Lu & Keller (1996)	Low to middle latitudes	Olsson et al. (1999)	54.45	59.35	Olsson et al. (1999)
Morozovella pasionensis	1	Shackleton et al. (1985); Lu & Keller (1996)	Low latitudes	Olsson et al. (1999)	54.45	59.5	Olsson et al. (1999)
Morozovella praeangulata	1	Shackleton et al. (1985)	Low to middle latitudes	Olsson et al. (1999)	60	61.15	Olsson et al. (1999)
Morozovella subbotinae	1	D'hondt et al. (1994)	Low to middle latitudes	Olsson et al. (1999)	50.8	55.9	Olsson et al. (1999)
Morozovella velascoensis	1	Berggren & Norris (1997)	Low to middle latitudes	Olsson et al. (1999)	54.45	59.9	Olsson et al. (1999)
Morozovelloides bandyi	1	Boersma et al. (1987); Pearson et al. (1993, 2001a)	Cosmopolitan	Pearson & Berggren (2006)	42.3	48.1	Pearson & Berggren (2006)
Morozovelloides coronatus	1	Wade et al. (2001); Wade & Kroon (2002)	Low latitudes	Pearson & Berggren (2006)	40.1	45.4	Pearson & Berggren (2006)
Morozovelloides crassatus	1	Boersma et al. (1987); Pearson et al. (1993, 2001a); Wade et al. (2001); Wade & Kroon (2002); Wade et al. (2008)	Low latitudes	Pearson & Berggren (2006)	38	45.9	Pearson & Berggren (2006)
Morozovelloides lehneri	1	Boersma et al. (1987); Pearson et al. (2007)	Low latitudes	Pearson & Berggren (2006)	40.1	44.65	Pearson & Berggren (2006)
Neogloboquadrina acostaensis	3	Pearson & Shackleton (1995)	Low latitudes	Kennett & Srinivasan (1983)	1.7	10.9	Kennett & Srinivasan (1983)
Neogloboquadrina continuosa	3	Keller (1985)	Low latitudes	Kennett & Srinivasan (1983)	7.8	23.2	FAD: Chaisson & Leckie (1993); LAD: Stott & Webb (1989)
Neogloboquadrina dutertrei	3	Kahn (1979); Shackleton & Vincent (1978)	Low latitudes	Kennett & Srinivasan (1983)	0	6.9	FAD: Chaisson & Leckie (1993); LAD: Kennett & Srinivasan (1983)
Neogloboquadrina humerosa	3	This study	Low latitudes	Kennett & Srinivasan (1983)	1.6	9.7	Chaisson & Pearson (1997)
Neogloboquadrina pachyderma	5	Vergnaud-Grazzini (1976)	Low to high latitudes	Kennett & Srinivasan (1983)	0	10.8	Chaisson & Pearson (1997)

Species name	**Eco-group**	**Eco-group reference**	**Geographic range**	**Geographic range reference**	**LAD**	**FAD**	**Date reference**
Orbulina suturalis	3	D. R. M. Stewart unpublished data	Low to middle latitudes	Kennett & Srinivasan (1983)	0	15.1	Kennett & Srinivasan (1983)
Orbulina universa	4	Vergnaud-Grazzini (1976)	Low to high latitudes	Kennett & Srinivasan (1983)	0	15.05	Kennett & Srinivasan (1983)
Orbulinoides beckmanni	1	This study	Low latitudes	Premoli Silva et al. (2006)	40	40.5	Premoli Silva et al. (2006)
Paragloborotalia acrostoma	3	This study	Low latitudes	Kennett & Srinivasan (1983)	12.6	23.2	Kennett & Srinivasan (1983)
Paragloborotalia bella	3	This study	Low latitudes	Kennett & Srinivasan (1983)	13.9	18.6	Kennett & Srinivasan (1983)
Paragloborotalia griffinoides	4	Pearson et al. (2001a)	High latitudes, high productivity/upwelling	Olsson et al. (2006c)	33.7	55.45	Olsson et al. (2006c)
Paragloborotalia incognita	3	This study	Low latitudes	Kennett & Srinivasan (1983)	16.4	20.9	Kennett & Srinivasan (1983)
Paragloborotalia kugleri	1	Keller (1985)	Low latitudes	Kennett & Srinivasan (1983)	21.5	23.8	Kennett & Srinivasan (1983)
Paragloborotalia mayeri	3	Pearson et al. (2001b); Pearson & Shackleton (1995)	Low latitudes	Kennett & Srinivasan (1983)	11.5	28	Kennett & Srinivasan (1983)
Paragloborotalia nana	3	Pearson & Wade (2009)	Low to middle latitudes	Olsson et al. (2006c)	15.1	47.5	Olsson et al. (2006c)
Paragloborotalia opima	3	Wade et al. (2007)	Cosmopolitan	Spezzaferri (1994)	27.1	30.3	Spezzaferri (1994)
Paragloborotalia pseudokugleri	1	Pearson & Wade (2009); Poore & Matthews (1984); Pearson et al. (1997b).	Low to middle latitudes and high productivity/upwelling	Spezzaferri (1994)	23.5	37.2	Spezzaferri (1994)
Paragloborotalia semivera	3	This study	Low latitudes	Kennett & Srinivasan (1983)	15.5	30.5	Kennett & Srinivasan (1983)
Paragloborotalia siakensis	3	Pearson & Wade (2009)	Low latitudes	Kennett & Srinivasan (1983)	11.4	30.3	Kennett & Srinivasan (1983)
Parasubbotina aff_*pseudobulloides*	4	Pearson et al. (2001a); D'hondt & Zachos (1993)	Cosmopolitan	Olsson et al. (1999)	64.8	65	Olsson et al. (1999)

Species name	Eco-group	Eco-group reference	Geographic range	Geographic range reference	LAD	FAD	Date reference
Parasubbotina eoclava	6	Coxall et al. (2003)	Low to middle latitudes and high productivity/upwelling	Olsson et al. (2006c)	44	49.25	Olsson et al. (2006c)
Parasubbotina griffinae	6	H. K. Coxall unpublished data	Low to middle latitudes and high productivity/upwelling	Olsson et al. (2006c)	37.3	48.4	Olsson et al. (2006c)
Parasubbotina inaequispira	6	Pearson et al. (2001a); H. K. Coxall unpublished data	Low to middle latitudes and high productivity/upwelling	Olsson et al. (2006c)	45.4	55.5	Olsson et al. (2006c)
Parasubbotina prebetica	6	This study	Known only from Spain	Olsson et al. (2006c)	50.9	51.7	Olsson et al. (2006c)
Parasubbotina pseudobulloides	4	D'hondt & Zachos (1993); Berggren & Norris (1997)	Cosmopolitan	Olsson et al. (1999)	59.7	64.9	Olsson et al. (1999)
Parasubbotina pseudowilsoni	3	This study	Low to middle latitudes	Olsson et al. (2006c)	40.5	47.6	Olsson et al. (2006c)
Parasubbotina varianta	3	Olsson et al. (1999); Pearson et al. (2001a)	Cosmopolitan	Olsson et al. (1999)	43	62.8	Olsson et al. (1999)
Parasubbotina variospira	3	Olsson et al. (1999); Pearson et al. (2001a)	Low latitudes	Olsson et al. (1999)	59.3	61	Olsson et al. (1999)
Planoglobanomalina pseudoalgeriana	2	This study	Low to middle latitudes	Olsson & Hemleben (2006)	45.2	50.8	Olsson & Hemleben (2006)
Planorotalites capdevilensis	2	Pearson et al. (2001a)	Low to middle latitudes	Berggren et al. (2006a)	38	50.4	Berggren et al. (2006a)
Planorotalites pseudoscitula	2	Pearson et al. (2001a)	Low to middle latitudes	Berggren et al. (2006a)	46.4	55.9	Berggren et al. (2006a)
Praemurica inconstans	2	Berggren & Norris (1997); Boersma & Premoli Silva (1983)	Cosmopolitan	Olsson et al. (1999)	60.9	62.8	Olsson et al. (1999)
Praemurica lozanoi	2	Pearson et al. (2001a)	Low to middle latitudes	Berggren et al. (2006a)	43	60.75	Berggren et al. (2006a)
Praemurica pseudoinconstans	2	This study	Low to middle latitudes	Olsson et al. (1999)	61.15	64.8	Olsson et al. (1999)
Praemurica taurica	2	Berggren & Norris (1997); D'hondt & Zachos (1993)	Cosmopolitan	Olsson et al. (1999)	63.8	64.9	Olsson et al. (1999)

Species name	Eco-group	Eco-group reference	Geographic range	Geographic range reference	LAD	FAD	Date reference
Praemurica uncinata	2	Berggren & Norris (1997); Shackleton et al. (1985)	Low to middle latitudes	Olsson et al. (1999)	60.7	61.2	Olsson et al. (1999)
Praeorbulina circularis	1	Pearson et al. (1997a)	Low to middle latitudes	Kennett & Srinivasan (1983)	14.9	15.7	Kennett & Srinivasan (1983)
Praeorbulina curva	1	Pearson et al. (1997a)	Low to middle latitudes	Kennett & Srinivasan (1983)	15	15.9	Kennett & Srinivasan (1983)
Praeorbulina glomerosa	1	Pearson et al. (1997a)	Low to middle latitudes	Kennett & Srinivasan (1983)	15	15.8	Kennett & Srinivasan (1983)
Praeorbulina sicanus	1	Pearson et al. (1997, 2001b)	Low to middle latitudes	Kennett & Srinivasan (1983)	14.8	16.4	Kennett & Srinivasan (1983)
Protentella nicobarensis	6	This study	Low latitudes	Kennett & Srinivasan (1983)	4	29.39	Kennett & Srinivasan (1983)
Protentella prolixa	6	This study	Low latitudes	Kennett & Srinivasan (1983)	11.4	29.4	Kennett & Srinivasan (1983)
Protentelloides dalhousiei	6	This study	Low latitudes	Zhang & Scott (1995)	25.7	23.8	Zhang & Scott (1995)
Protentelloides primitiva	6	This study	Low latitudes	Zhang & Scott (1995)	26.3	23.8	Zhang & Scott (1995)
Pseudoglobigerinella bolivariana	6	Pearson et al. (2006)	Low latitudes and high productivity/upwelling	Olsson et al. (2006c)	43.1	48.1	Olsson et al. (2006c)
Pseudohastigerina micra	2	Poore & Matthews (1984); Boersma et al. (1987); Pearson et al. (2001a)	Low to high latitudes	Olsson & Hemleben (2006)	32.2	48.1	Olsson & Hemleben (2006)
Pseudohastigerina naguewichiensis	2	Wade & Pearson (2008)	Low to high latitudes	Olsson & Hemleben (2006)	32	35.8	Olsson & Hemleben (2006)
Pseudohastigerina sharkriverensis	2	This study	Middle latitudes only	Olsson & Hemleben (2006)	39.3	48	Olsson & Hemleben (2006)
Pseudohastigerina wilcoxensis	2	This study	Low to high latitudes	Olsson & Hemleben (2006)	43.3	55.3	Olsson & Hemleben (2006)
Pulleniatina finalis	3	This study	Low latitudes	This study	0	4.25	Chaisson & Pearson (1997)
Pulleniatina obliquiloculata	3	Shackleton & Vincent (1978); Pearson & Shackleton (1995)	Low latitudes	Kennett & Srinivasan (1983)	0	5.6	Chaisson & Pearson (1997)

Species name	Eco-group	Eco-group reference	Geographic range	Geographic range reference	LAD	FAD	Date reference
Pulleniatina praecursor	3	This study	Low latitudes	Kennett & Srinivasan (1983)	1.75	6.8	Banner & Blow (1967)
Pulleniatina praespectabilis	3	This study	Low latitudes	Bolli & Saunders (1985)	4.4	4.6	Banner & Blow (1967)
Pulleniatina primalis	3	This study	Low latitudes	Kennett & Srinivasan (1983)	1.3	5.7	Chaisson & Pearson (1997)
Pulleniatina spectabilis	3	This study	Low latitudes	Kennett & Srinivasan (1983)	4.2	5.2	Banner & Blow (1967)
Sphaeroidinella dehiscens	3	Shackleton & Vincent (1978)	Low latitudes	Kennett & Srinivasan (1983)	0	5.6	FAD: Kennett & Srinivasan (1983); LAD: Chaisson & Pearson (1997)
Sphaeroidinellopsis disjuncta	3	This study	Low latitudes	Kennett & Srinivasan (1983)	12.1	18.1	Kennett & Srinivasan (1983)
Sphaeroidinellopsis kochi	3	This study	Low latitudes	Kennett & Srinivasan (1983)	3.6	14.4	FAD: Kennett & Srinivasan (1983); LAD: Chaisson & Pearson (1997)
Sphaeroidinellopsis paenedehiscens	3	Pearson & Shackleton (1995)	Low latitudes	Kennett & Srinivasan (1983)	2.3	7.1	FAD: Kennett & Srinivasan (1983); LAD: Chaisson & Pearson (1997)
Sphaeroidinellopsis seminulina	3	D. R. M. Stewart unpublished data	Low latitudes	Kennett & Srinivasan (1983)	2.3	16.4	FAD: Kennett & Srinivasan (1983); LAD: Chaisson & Pearson (1997)
Subbotina angiporoides	3	Poore & Matthews (1984); Coxall et al. (2000)	Cosmopolitan	Olsson et al. (2006a)	28.5	42.3	FAD: Olsson et al. (2006a); LAD: B.S. Wade & P. N. Pearson in preparation
Subbotina cancellata	3	Coxall et al. (2000)	Unknown, but found in North and South Atlantic	Olsson et al. (1999)	56.8	61.2	Olsson et al. (1999)
Subbotina corpulenta	3	Coxall et al. (2000); Wade & Pearson (2008)	Low to middle latitudes	Olsson et al. (2006a)	32.1	47.25	FAD: Olsson et al. (2006a); LAD: B.S. Wade & P. N. Pearson in preparation
Subbotina crociapertura	4	Coxall et al. (2000); Pearson et al. (2001a)	Low latitudes	Olsson et al. (2006a)	40	46.4	Olsson et al. (2006a)

Species name	Eco-group	Eco-group reference	Geographic range	Geographic range reference	LAD	FAD	Date reference
Subbotina eocaena	4	Boersma et al. (1987); Coxall et al. (2000); Pearson et al. (2001a); Wade et al. (2007); Wade & Pearson (2008)	Low to middle latitudes	Olsson et al. (2006a)	32.2	50.7	FAD: Olsson et al. (2006a); LAD: B.S. Wade & P. N. Pearson in preparation
Subbotina gortanii	4	Coxall et al. (2000); Pearson et al. (2001a)	Low to middle latitudes	Olsson et al. (2006a)	27.2	39.1	FAD: Olsson et al. (2006a); LAD: B.S. Wade & P. N. Pearson in preparation
Subbotina hagni	3	Coxall et al. (2000)	Low to middle latitudes	Olsson et al. (2006a)	34.3	48.1	Olsson et al. (2006a)
Subbotina hornibrooki	3	Coxall et al. (2000)	Low to middle latitudes	Olsson et al. (2006a)	52.5	55.6	Olsson et al. (2006a)
Subbotina jacksonensis	3	Coxall et al. (2000)	Low to middle latitudes	Olsson et al. (2006a)	33.7	43.8	Olsson et al. (2006a)
Subbotina linaperta	3	Poore & Matthews (1984) Pearson et al. (1993); Coxall et al. (2000)	Cosmopolitan	Olsson et al. (2006a)	33.7	52	FAD: Olsson et al. (2006a); LAD: B.S. Wade & P. N. Pearson in preparation
Subbotina patagonica	4	Pearson & Palmer (1999); Coxall et al. (2000)	Cosmopolitan	Olsson et al. (2006a)	45.15	57	Olsson et al. (2006a)
Subbotina roesnaesensis	3	Coxall et al. (2000)	Low to middle latitudes	Olsson et al. (2006a)	43.2	55.6	Olsson et al. (2006a)
Subbotina senni	5	Pearson et al. (1993, 2001a); Coxall et al. (2000)	Low to middle latitudes	Olsson et al. (2006a)	38	50.6	Olsson et al. (2006a)
Subbotina sp1	3	Coxall et al. (2000)			32.6	34.1	B.S. Wade & P. N. Pearson in preparation
Subbotina sp2	3	Coxall et al. (2000)			27.2	33.8	B.S. Wade & P. N. Pearson in preparation
Subbotina triangularis	2	D'hondt et al. (1994); Coxall et al. (2000)	Low to middle latitudes	Olsson et al. (1999)	55.55	61.1	Olsson et al. (1999)
Subbotina triloculinoides	3	Berggren & Norris (1997); Coxall et al. (2000)	Cosmopolitan	Olsson et al. (1999)	59.3	64.3	Olsson et al. (1999)
Subbotina trivialis	3	Coxall et al. (2000)	Cosmopolitan	Olsson et al. (1999)	61	64.92	Olsson et al. (1999)

Species name	Eco-group	Eco-group reference	Geographic range	Geographic range reference	LAD	FAD	Date reference
Subbotina utilisindex	4	Poore & Matthews (1984); Coxall et al. (2000); Wade & Kroon (2002)	Cosmopolitan	Olsson et al. (2006a)	30.3	35.4	FAD: Olsson et al. (2006a); LAD: B.S. Wade & P. N. Pearson in preparation
Subbotina velascoensis	3	Berggren & Norris (1997); Coxall et al. (2000)	Cosmopolitan	Olsson et al. (1999)	54.45	59.2	Olsson et al. (1999)
Subbotina yeguaensis	4	Boersma et al. (1987); Coxall et al. (2000)	Cosmopolitan	Olsson et al. (2006a)	33.7	50.4	Olsson et al. (2006a)
Truncorotalia cavernula	4	This study	Middle latitudes	Kennett & Srinivasan (1983)	0	0.9	D. R. M. Stewart unpublished data
Truncorotalia crassaconica	4	This study	Low to middle latitudes	This study	3.5	4.3	D. R. M. Stewart unpublished data
Truncorotalia crassaformis	4	D. R. M. Stewart unpublished data	Low to middle latitudes	Kennett & Srinivasan (1983)	0	5.7	D. R. M. Stewart unpublished data
Truncorotalia crassula	4	Shackleton & Vincent (1978)	Low latitudes	Kennett & Srinivasan (1983)	0.9	5.55	FAD: D. R. M. Stewart unpublished data; LAD: Jenkins & Orr (1972)
Truncorotalia excelsa	4	This study	Low to middle latitudes	Kennett & Srinivasan (1983)	0	1.85	D. R. M. Stewart unpublished data
Truncorotalia hessi	4	This study	Low to middle latitudes	Kennett & Srinivasan (1983)	0.4	1.8	D. R. M. Stewart unpublished data
Truncorotalia oceanica	4	This study	Low to middle latitudes	Kennett & Srinivasan (1983)	0	5.5	D. R. M. Stewart unpublished data
Truncorotalia pachytheca	4	This study	Low latitudes	Kennett & Srinivasan (1983)	0	1.8	D. R. M. Stewart unpublished data
Truncorotalia ronda	4	This study	Low to middle latitudes	Kennett & Srinivasan (1983)	1	4	D. R. M. Stewart unpublished data
Truncorotalia tenuitheca	4	This study	Low latitudes	Kennett & Srinivasan (1983)	1.3	3.4	D. R. M. Stewart unpublished data
Truncorotalia tosaensis	4	Shackleton & Vincent (1978)	Low latitudes	Kennett & Srinivasan (1983)	1.2	3.2	Chaisson & Leckie (1993)

Species name	**Eco-group**	**Eco-group reference**	**Geographic range**	**Geographic range reference**	**LAD**	**FAD**	**Date reference**
Truncorotalia truncatulinoides	4	Vergnaud-Grazzini (1976); Shackleton & Vincent (1978)	Low latitudes	Kennett & Srinivasan (1983)	0	1.9	D. R. M. Stewart unpublished data
Truncorotalia viola	4	This study	Low to middle latitudes	Kennett & Srinivasan (1983)	1.4	3.5	D. R. M. Stewart unpublished data
Turborotalia altispiroides	2	Pearson et al. (2001a)	Cosmopolitan	Pearson et al. (2006)	37.2	40.8	Pearson et al. (2006)
Turborotalia ampliapertura	2	Pearson et al. (2007)	Cosmopolitan	Pearson et al. (2006)	30.3	35	Pearson et al. (2006)
Turborotalia cerroazulensis	2	Pearson et al. (2007)	Cosmopolitan	Pearson et al. (2006)	33.8	41.8	Pearson et al. (2006)
Turborotalia cocoaensis	3	Pearson et al. (2007)	Cosmopolitan	Pearson et al. (2006)	33.8	38.6	Pearson et al. (2006)
Turborotalia cunialensis	2	This study	Cosmopolitan	Pearson et al. (2006)	33.8	34.1	Pearson et al. (2006)
Turborotalia euapertura	4	Pearson et al. (1997b, 2007)	Cosmopolitan	This study	30.25	32.65	NEPTUNE
Turborotalia frontosa	4	Boersma et al. (1987); Pearson (1993); Pearson et al. (2001a)	Cosmopolitan	Pearson et al. (2006)	40.8	48.7	Pearson et al. (2006)
Turborotalia increbescens	2	Pearson et al. (2007)	Cosmopolitan	Pearson et al. (2006)	30.3	39.2	Pearson et al. (2006)
Turborotalia pomeroli	2	Boersma et al. (1987); Pearson et al. (2001a)	Cosmopolitan	Pearson et al. (2006)	34.6	43.2	Pearson et al. (2006)
Turborotalia possagnoensis	2	Poore & Matthews (1984)	Cosmopolitan	Pearson et al. (2006)	40.8	43.95	Pearson et al. (2006)
Turborotalita carcoselleensis	2	This study	Low to middle latitudes	Olsson et al. (2006a)	35.9	44.4	Olsson et al. (2006a)
Turborotalita clarkei	2	This study	Low latitudes	Brummer & Kroon (1988)	0	1.6	Hemleben et al. (1989)
Turborotalita cristata	2	This study	Low latitudes	Kennett & Srinivasan (1983)	0	4.5	NEPTUNE
Turborotalita humilis	2	This study	Low latitudes	Kennett & Srinivasan (1983)	0	6	Kennett & Srinivasan (1983)
Turborotalita praequinqueloba	2	This study	Low latitudes	Olsson et al. (2006a)	22.4	36	Olsson et al. (2006a)
Turborotalita quinqueloba	5	Pearson & Wade (2009)	Low to high latitudes	Kennett & Srinivasan (1983)	0	25.4	Kennett & Srinivasan (1983)

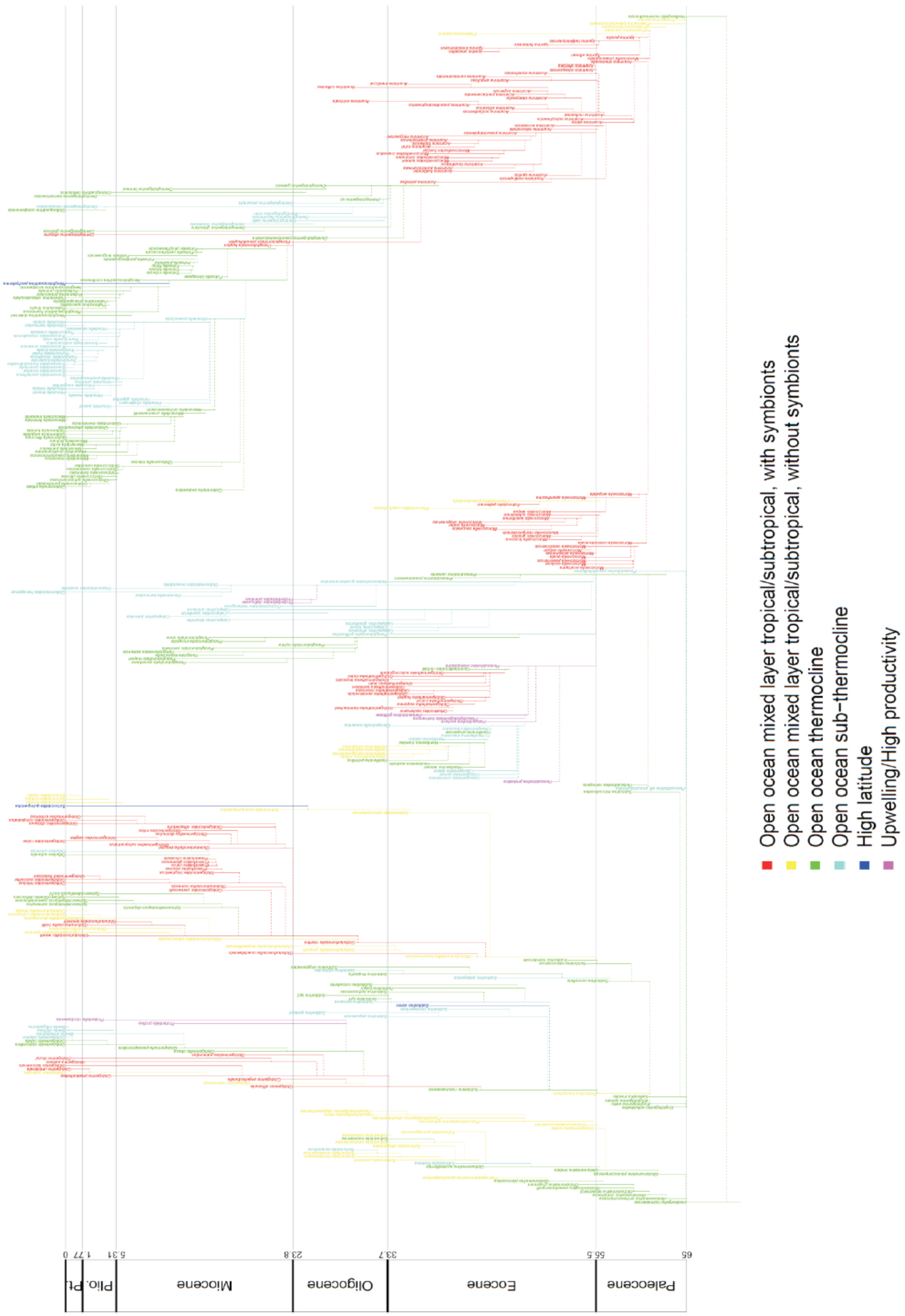


Figure 2.8 The morphospecies phylogeny with each species assigned to its respective ecogroup. A legible version of this figure is provided in the Electronic Appendix - Part B.

2.4. Prospects

Lineage phylogenies here presented provide the closest approximation to the theoretical and simulated phylogenies that have underpinned many of the palaeobiological developments in macroevolution (e.g. Raup *et al*., 1973; Raup, 1985; Foote, 2001; Roy & Goldberg, 2007), and so provide the most promising system available for testing a range of macroevolutionary hypotheses (Purvis, 2008; Benton, 2009). The frequency of pseudospeciation and pseudoextinction is not known in general, but is a source of noise and bias in macroevolutionary analyses. Approximately 40% of morphospecies extinctions to be pseudoextinctions within this clade. Many previous analyses of rates of first and last appearances of taxa in planktonic foraminifera (e.g. Pearson, 1995; Allen *et al*., 2006; Doran *et al*., 2006;) have therefore mixed cladogenesis and extinction on the one hand with anagenesis on the other. Both processes are of interest, and lineage phylogenies permit them to be disentangled.

As well as attempting to eliminate pseudospeciation, the two lineage phylogenies embody different species concepts, which support different kinds of question. For example, it is reasonable to ask of evolutionary species, but not of Hennigian species, whether production of daughter species affects their own survival and future speciation potential (Pearson, 1998*b*). The different concepts also yield different ages for species. The ages of evolutionary species (Simpson, 1951; Wiley, 1978) have more natural evolutionary meanings than either the time since first appearance of a morphospecies (commonly used in palaeobiology) or the time since the most recent common ancestor shared with another extant species (commonly used in phylogenetic comparative studies). The importance of this additional, biologically-relevant information present in lineage phylogenies is an interesting open question.

Cryptic diversity presents another challenge for macroevolutionary studies, the resolution of which will require input from both molecular phylogeneticists and morphologists. Algorithmic approaches have been developed for delimiting genetic species based on either single genes (e.g. Pons *et al*., 2006) or multiple unlinked loci (e.g. Knowles & Carstens, 2007). Application of these approaches to planktonic foraminifera would provide a valuable line of evidence on the frequency of cryptic species, and is facilitated by three ongoing developments: (1) geographic sampling continues to improve (Darling & Wade, 2008); (2) efforts to sequence additional genes to SSU rRNA continue (Longet

& Pawlowski, 2007); and (3) DNA extraction no longer requires complete dissolution of the test (Morard *et al*., 2009). Morphometricians will therefore increasingly be able to analyse the same specimens from which gene sequences are taken, which will greatly enhance the prospects for a fully integrative taxonomy (Vogler & Monaghan, 2007) as well as permitting powerful characterisation of the selective regime under which morphology evolves (Fontaneto *et al*., 2007). Moving to the fossil record, detailed morphometric and geochemical analyses focusing on periods bracketing apparent speciation events may detect previously unrecognised cryptic diversity (Hull & Norris, 2009) and clarify how anagenesis and cladogenesis are linked.

Although molecular sequence data will be key for species delimitation, the prospects for using them to resolve deep splits in the phylogeny seem less promising. The fossil evidence suggests that many pairs of extant species share their most recent common ancestor in the first ten million years of the clade's radiation and resolution of such short branches so long ago typically requires very large numbers of unlinked genes (Rokas *et al*., 2005). However, the detailed knowledge of past species and environments mean that the group may provide rare opportunities for testing hypotheses for variation in the rate of molecular evolution among lineages.

The construction of lineage phylogenies requires a combination of a comprehensive fossil record, detailed morphospecies-level taxonomic work, and consistency in the use of taxonomic concepts. At present, Cenozoic macroperforate planktonic foraminifera are perhaps the only group for which all the conditions are met; however, the approach will increasingly be possible for other well-known groups, either globally or in particularly well-studied regions, as knowledge of fossil taxa and their relationships continues to accumulate.

2.5 Summary

The phylogenies presented herein are the first synthesis of this group for the whole Cenozoic since Fordham (1986). The evolutionary relationships detailed within the Paleocene and Eocene are likely to be the most robust, due to the recent publication of Atlases by the Paleogene planktonic foraminifera working group (Olsson *et al*., 1999; Pearson *et al*., 2006). Attention is required in the late Paleogene and Neogene, with particular focus needed upon the origin of the globorotaliid clade. The Paleogene Working Group is currently preparing the *Atlas of Oligocene Planktonic Foraminifera*, which will complete the major revision of the Paleogene planktonic foraminifera begun in 1987. As a consequence of the continuing endeavours of the many scientific workers focusing their efforts upon more detailed morphometric and genetic analysis of this group, it is anticipated that some of the relationships detailed herein may change or be falsified by new work.

The synthesis of many phylogenies into one large phylogeny provides the opportunity to appreciate graphically the evolutionary history of this exceptional fossil group. The phylogenies provide frameworks and testable hypotheses for macroevolutionary investigation of how morphologically complex organisms recover and radiate after abrupt climatic upheaval.

3. Macroevolution of Cenozoic macroperforate planktonic foraminifera

3.1 Introduction

The Cenozoic is characterised by extreme and often abrupt environmental change against a backdrop of long term gradual warming and cooling trends (Zachos *et al*., 2001, 2008). The information about stratigraphic range, morphology and ecology of all macroperforate planktonic foraminifera species presented in Chapter 2 allows for a narrative description of their evolutionary development over this dynamic period.

This chapter addresses the narrative history of planktonic foraminifera with particular reference to their environment and ecological preference. The palaeoproxy used for temperature is the $\delta^{18}O$ stack of deep-sea benthic foraminiferal calcite constructed by Zachos *et al*. (2008). It is acknowledged that the $\delta^{18}O$ temperature proxy records a high latitude signal and the term 'latitudinal thermal gradient' refers to the pole to equator temperature disparity that is inferred from this curve; the gradient will increase during cold periods as tropical sea-surface temperatures have probably remained relatively more constant throughout the Cenozoic (Pearson *et al*., 2001). Factors such as salinity, penetration of sunlight and quantity of dissolved oxygen are known to influence the species ecologies and distributions of planktonic foraminifera (Norris, 2000) but as these parameters not quantifiable over deep time they are not accounted for in the following discussion.

3.2 Summary evolutionary history of the Cenozoic macroperforate planktonic foraminifera

3.2.1 Post-K/Pg recovery

A large bolide impact at the Cretaceous/Paleocene (K/Pg) transition 65 Ma initiated a mass extinction that caused a biological turnover of unprecedented scale; many animal groups were wiped out or suffered from near total species level extinction (Schulte *et al*., 2010). In the marine realm the extreme environmental stress following the impact resulted in a marked perturbation of oceanic biogeochemical processes (D'Hondt, 2005). The production of marine plankton calcium carbonate ($CaCO_3$) dramatically declined resulting in the $CaCO_3$ component of deep-sea sediments reducing to nearly zero

(D'Hondt, 2005). There was a near complete cessation of organic matter delivered to the seafloor which is thought to reflect a rapid decrease in primary productivity (D'Hondt *et al*., 1998; Coxall *et al*, 2006) and the diversity of fossilized marine genera was reduced by nearly 50% (D'Hondt, 2005). The macroperforate planktonic foraminifera survived the K/Pg mass extinction, but only just. Their diversity prior to this event was approximately 50 morphospecies which included large, ornate genera such as *Contusotruncana*, *Racemiguembelina* and *Globotruncana* (Caron, 1985) but only two species survived into the Cenozoic, *Hedbergella holmdelensis* and *H. monmouthensis* (Olsson *et al*., 1999). Both were small, non-spinose forms living in the upper ocean mixed-layer (Olsson *et al*., 1999; Heather Birch, pers. comm. 2011) and it has been suggested that the small size and surface-water generalist lifestyle of the hedbergellids provided the ability to transition the enormous environmental perturbations at the K/Pg (Stanley, 1973).

Following the K/Pg net primary productivity began to recover after about 0.5 million years (myr) but it wasn't until 2-3 myr after the event that delivery of organic material to the seafloor returned to pre-event levels (Coxall *et al*., 2006). The evolutionary recovery of macroperforate planktonic foraminifera occurred in two stages which very closely matched the recovery of marine carbon cycling. In the initial 300,000 year recovery period of the early Paleocene, the roots of the major clades of Cenozoic macroperforate planktonic foraminifera were established with the appearance of nine new morphospecies (Figures 3.1.A & 3.2). The praemuricates were living in the mixed layer and the non-spinose genera *Globanomalina and Eoglobanomalina* were living in the thermocline with the spinose, globular forms *Parasubbotina* and *Subbotina.* Currently it is suggested that the sub-thermocline was uninhabited by macroperforate planktonic foraminifera (Helen Coxall, pers. comm. 2011).

A second pulse of diversification occurred approximately 3 myr after the K/Pg event that is largely attributed to the origination of the morozovellids. This was roughly coincident with the full recovery of the oceanic biological carbon pump; organic material was once again being readily delivered to the sea floor resulting in oligotrophic surface waters stripped of nutrients (Coxall *et al*. 2006). The morozovellids were a surface dwelling genus with a $\delta^{13}C$ signature associated with symbiosis. The origination of a successful and diverse symbiotic group is consistent with increased nutritional requirements due to the decline of available nutrients in the surrounding waters (Coxall *et al*. 2006).

The descendants of the genera that originated during this recovery period went on to dominate the planktonic foraminiferal assemblage by the end of the Danian (61.85 Ma) (D'Hondt, 2005).

3.2.2 Paleocene

Following the recovery from the K/Pg event global temperatures remained relatively constant throughout the early Paleocene (see Figure 3.3) and macroperforate planktonic foraminiferal diversity increased steadily. Fundamental changes in the wall texture of these species have been attributed to adaptation to the rapidly changing water-mass environment of the early Paleocene (Olsson *et al*., 1999). Most significant was the development of the cancellate and muricate wall ultra-structures which were innovations of the early Cenozoic (Olsson *et al*., 1999).

The 'honeycomb' structure of the cancellate wall can be found on species that are both spinose and non-spinose and results from the lateral growth of pustules into smooth ridges surrounding surface pores (Olsson *et al*., 1999); the cancellate wall texture has been prevalent throughout the whole Cenozoic and is still found on modern day representatives. The development of spines was an innovation that arose in the earliest Cenozoic (Hemleben *et al*., 1991), and is hypothesized to indicate a transition to a carnivorous feeding niche and the initiation of hosting photosynthetic algal symbionts (D'Hondt & Zachos, 1993; Olsson *et al*., 1999).

The non-spinose, muricate wall is characterised by heavy pustulose growths; these are ontogenetic layered structures upon the surface of the test and are characteristic of the genera *Acarinina* and *Morozovella* (Olsson *et al*., 1999). Muricate species exhibit a marked positive correlation between $\delta^{13}C$ and test size which has been attributed to symbiotic fractionation (Pearson *et al*., 1993; Norris, 1996). A hypothesis regarding the functionality of muricae is that they may have served a similar purpose as spines in modern symbiotic forms; the pustulose growths would provide a greater surface area to harbour a greater number of symbionts. This is a testable hypothesis; if the number, density and size of muricae increase through time so would the test surface area and if this is favourable for hosting greater numbers of algal symbionts there should be an increasingly positive correlation of $\delta^{13}C$ associated with increase of muricae. To the author's knowledge this has yet to be tested.

Towards the end of the late Paleocene temperatures were starting to rise and approximately 30 distinct morphospecies have been captured in the sediment record (Figure 3.2). The tropical surface waters were home to the highly successful muricate genera *Acarinina* and *Morozovella*, which by the end of the Paleocene constituted half of the total diversity of the clade. Spinose parasubbotinids were found in shelf environments, upwelling and deep water, and the thermocline was dominated by smooth-walled globanomalinids and spinose subbotinids (Figure 3.1.B). The diversity at the end of the Paleocene did not match the pre- K/Pg population, but the assemblage did once again include some large and ornate forms typical of more stable environmental conditions (Pearson *et al*., 2008*b*).

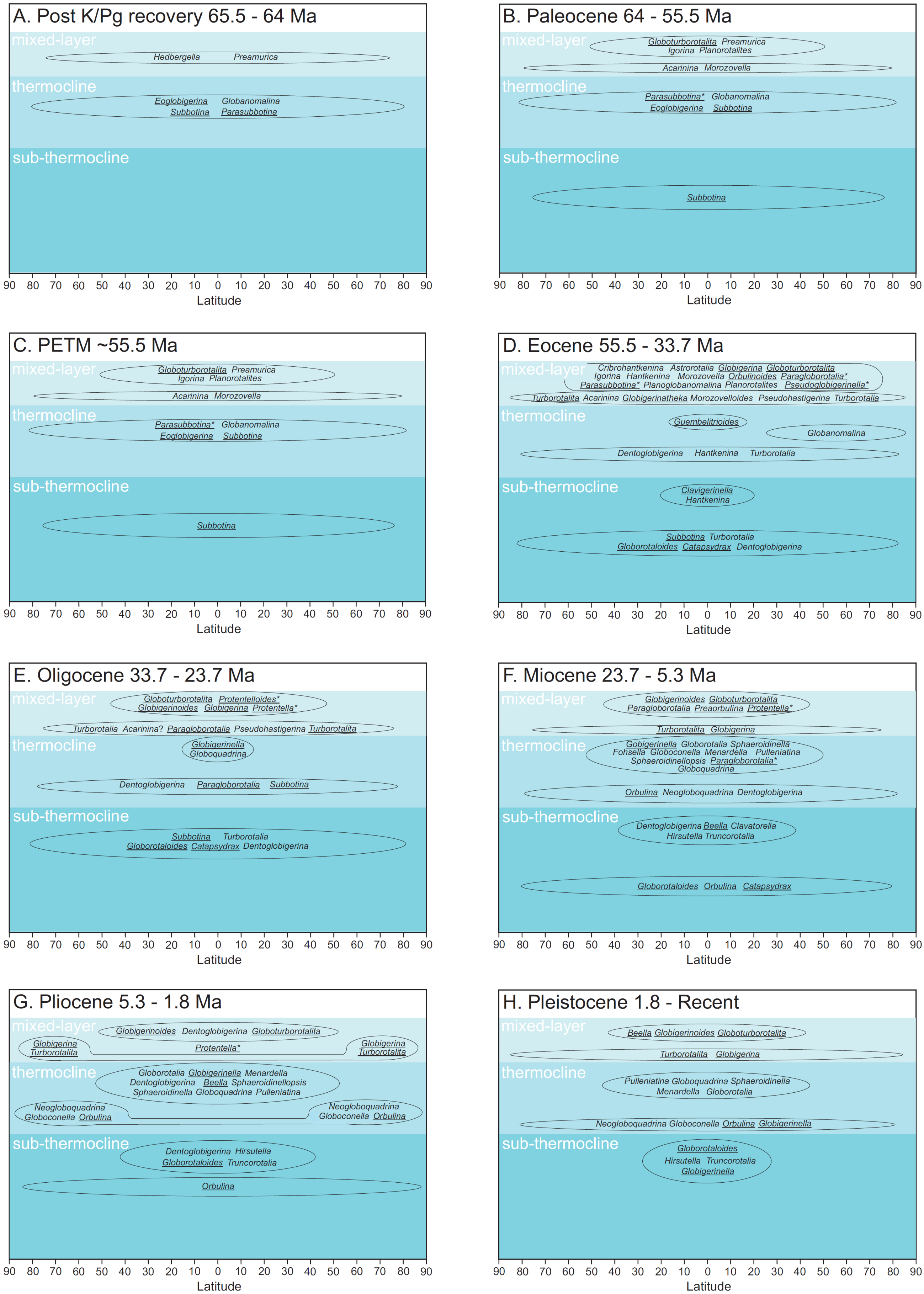


Figure 3.1 Please see next page for figure caption

Figure 3.1 A schematic illustration of macroperforate planktonic foraminifera diversification throughout the Cenozoic with panels showing the six separate epochs and two important events (the K/Pg recovery and the PETM). The genera are grouped by ecological and geographic preference based upon the information presented in Chapter 2. The vertical ordering of genera within each depth horizon is for graphical purposes and is not a reflection of depth preference e.g. all genera within the mixed-layer are assumed to exploit the same depth habitat but are grouped according to their latitudinal preferences. Genera which are underlined are spinose forms and genera denoted with * are associated with upwelling environments. It is acknowledged that the depth of the mixed-layer, thermocline and sub-thermocline horizons vary latitudinally and through time but for graphical purposes they are static in this schematic. For ecological, morphological and stratigraphic details at the specific level see Tables 2.2 and 2.4. The periods represented in the panels are as follows: (A) Post K/Pg recovery period 65.5 – 64 Ma: only six genera are present at this time with a total of 9 distinct morphospecies. There are no spinose forms and no species living in the thermocline. (B) The main body of the Paleocene epoch 64 – 55.5 Ma: the number of genera increases from 6 to 10 and new ecological strategies are exploited; the genus *Subbotina* descends into the sub-thermocline and groups living in the mixed-layer and thermocline acquire spines and photosymbionts. (C) The PETM ~ 55.5 Ma: generic level diversity appears static but there was a high species level turnover at this time with the appearance of short-lived excursion taxa and a pole-wards migration of forms that transitioned the event. (D) The Eocene epoch 55.5 – 33.7 Ma: the highest level of diversity throughout the entire Cenozoic. This was particularly evident in the mixed-layer which had many geographically cosmopolitan spinose and non-spinose forms. There were a number of genera associated with upwelling and many new genera exploiting the thermocline and sub-thermocline environments. At this time a transition between water depth horizons over time is expressed morphologically and geochemically in the genera *Hantkenina* and *Turborotalia*. The highly diverse assemblages of the Eocene are comparable to the ecological and geographical niche exploitation of modern day populations. (E) The Oligocene Epoch 33.7 – 23.7 Ma: a considerable decrease in mixed-layer generic diversity occurred, a significant proportion of low latitude non-spinose forms are lost from this environment. In the thermocline and sub-thermocline the composition of the assemblages changed but diversity remained relatively constant. (F) The Miocene epoch 23.7 – 5.3 Ma: generic mixed-layer diversity decreased further in the Miocene but there was a marked increase in generic diversity in the thermocline (from 5 to 13 different genera) and sub-thermocline (from 5 to 8 different genera). This is mostly due to the origination of the highly successful globorotaliid clade in the early Miocene. (G) The Pliocene epoch 5.3 – 1.8 Ma: the thermocline environment remains the most diverse and there is a small decrease in generic diversity in both the mixed layer and the sub-thermocline. (H) The Pleistocene epoch 1.8 – recent: generic diversity decreases in all environments but not significantly. The mixed layer is now inhabited only by spinose forms and the deeper water depths continue to be inhabited by both spinose and non-spinose genera.

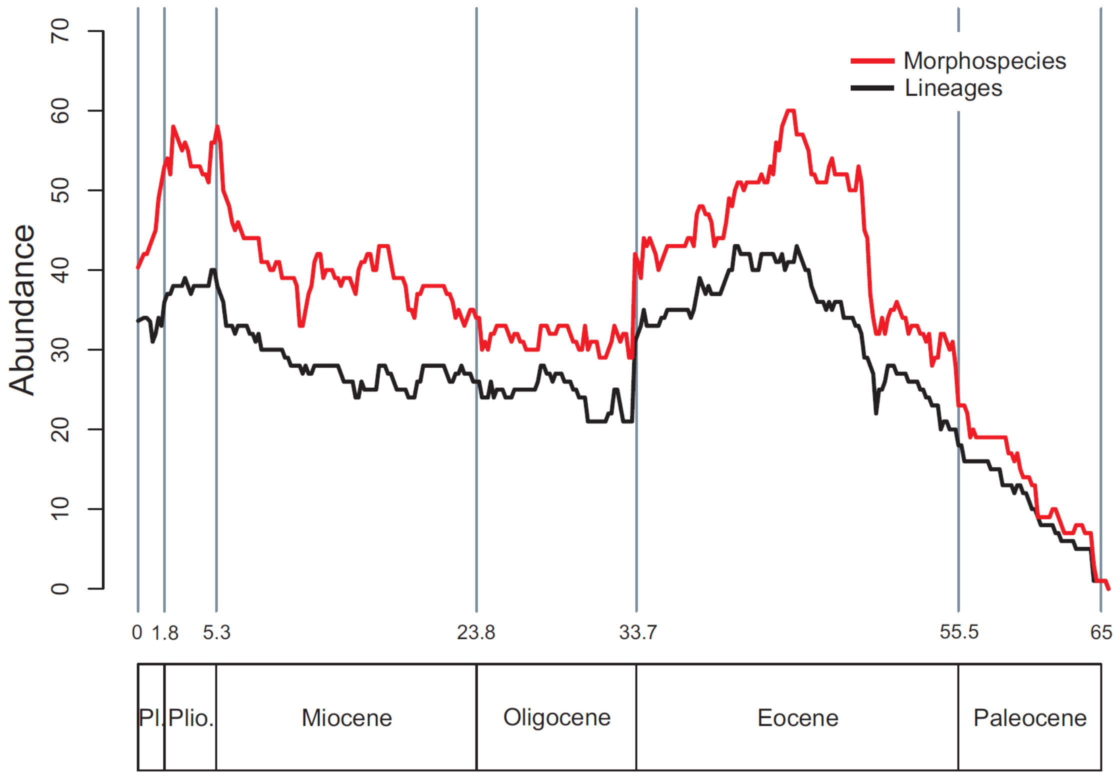


Figure 3.2 A curve illustrating total diversity of macroperforate planktonic foraminifera as both morphospecies (red) and evolutionary lineages (black) from 65 Ma to the present day. The diversity curves are derived from the stratigraphic ranges detailed in Table 2.4 and Electronic Appendix Part C.

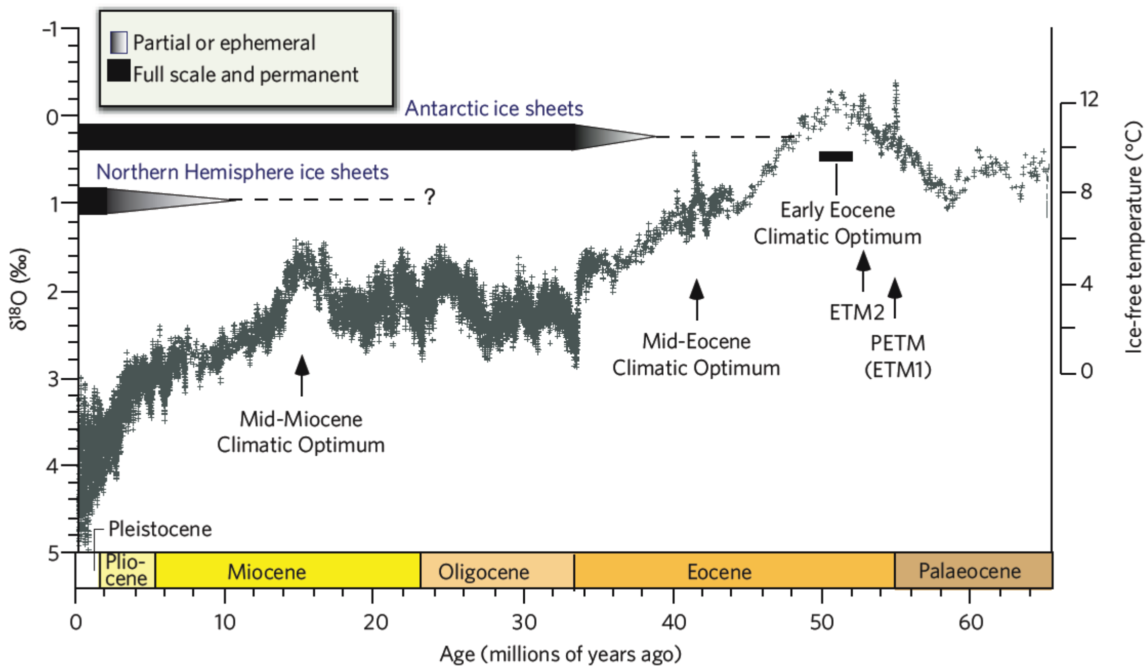


Figure 3.3 A climate curve taken from Zachos *et al*. (2008). The curve is a stacked deep-sea benthic foraminiferal oxygen-isotope curve which has been smoothed by a 5 point running mean. The curve illustrates changes in global climate over the past 65 million years. PETM and ETM2 refer to the Paleocene/Eocene thermal maximum and the Eocene thermal maximum 2 respectively.

3.2.2 The Paleocene/Eocene Thermal Maximum (PETM)

Approximately 55.5 million years ago a vast amount of isotopically light carbon was released into the atmosphere. This initiated an extreme and abrupt warming event which resulted in a global temperature rise of between 4-5˚C (Zachos *et al*., 2005, 2007) lasting approximately 170 thousand years (kyr) (Röhl *et al*., 2007). In the marine realm, sea-surface and deep-sea temperatures increased by 5-8˚C (e.g. Thomas *et al*., 2003) parallel with extensive seafloor carbonate dissolution resulting from a shoaling of the $CaCO_3$ compensation depth (Zachos *et al*., 2005; Pagani *et al*., 2006). This change in the carbonate dissolution horizon is consistent with rapid ocean acidification due to increased atmospheric CO_2 (Zachos *et al*., 2005).

During the PETM, macroperforate planktonic foraminiferal diversity expressed little more than a gradual and steady increase in number of morphospecies and lineages (Figure 3.2). However, this is a superficial observation and if broken down into extinctions and originations it is clear that this was a dynamic period for the clade. Figure 3.4 illustrates that the highest proportion of lineage and morphospecies originations and extinctions for the entire Cenozoic occurred at this time. In spite of this high turnover the macroperforate planktonic foraminifera transitioned the PETM with relative success, especially when compared to the extinction event associated with the environmental stresses of K/Pg 10 myr earlier. Their evolutionary response demonstrates a high resilience to the environmental perturbations of the PETM in that no genera became extinct at the boundary (Figure 3.1.C). Several mechanisms have been proposed for their evolutionary coping strategies; the strong size-dependant $\delta^{13}C$ and $\delta^{18}O$ signatures of the muricate genera suggest that their photosymbiotic relationships helped them to transition the intensely oligotrophic PETM oceans (Kelly, Bralower & Zachos, 1998); in the tropical Pacific the appearance of excursion taxa such as *Acarinina sibaiyaensis*, *A. Africana* and *Morozovella allisonensis* is suggested to be related to the deepening of a nutrient-depleted mixed-layer or to represent failed speciations of extreme ecophenotypic variants from an enhanced ecological gradient (Kelly *et al*., 1998); in the Indian Ocean the excursion taxa are also present and it is suggested that the clade adapted through pole-ward migrations (Bown & Pearson, 2009).

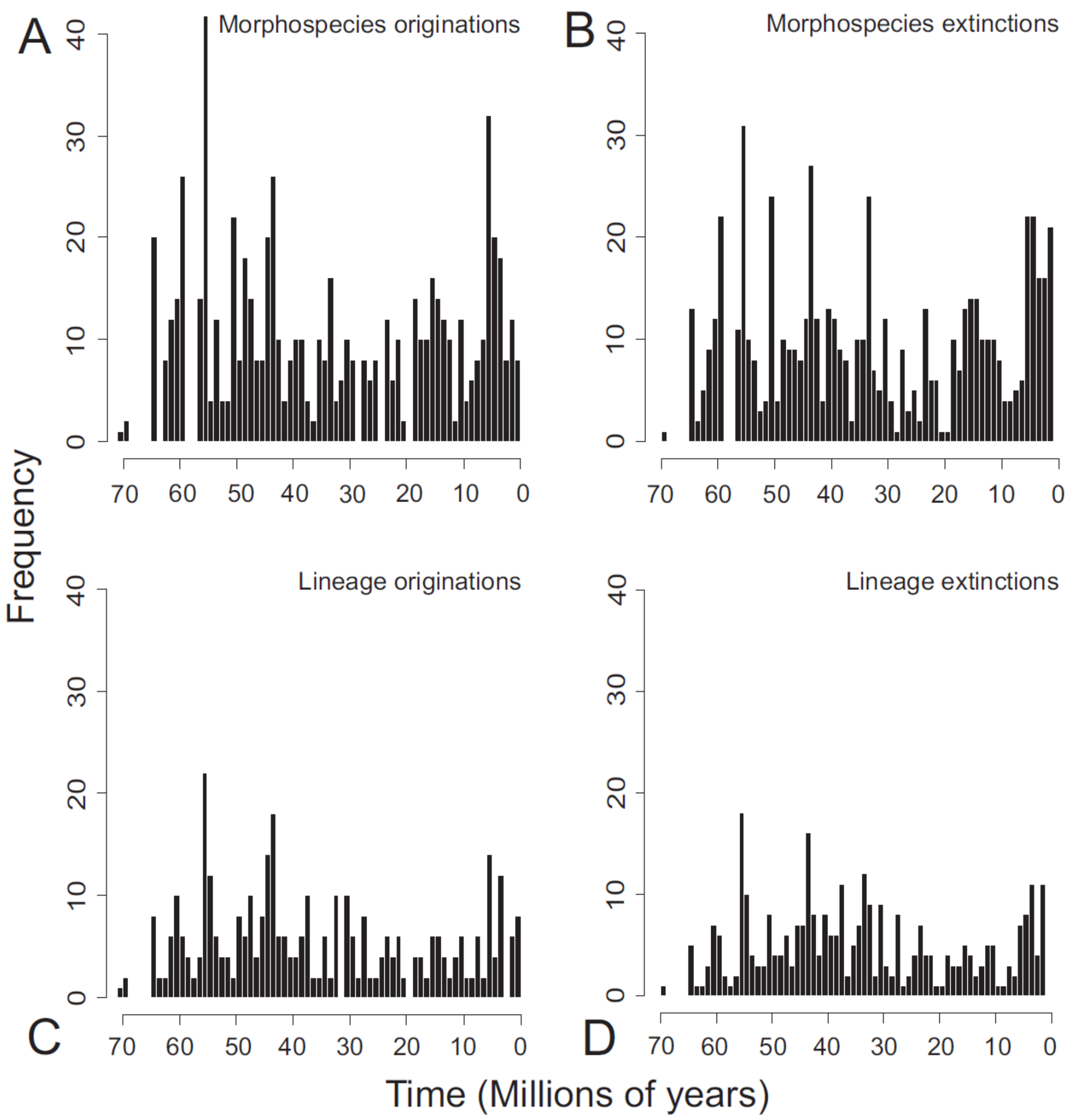


Figure 3.4 A figure illustrating macroperforate planktonic foraminifera extinctions and speciations throughout the Cenozoic based upon the stratigraphic range information presented in Chapter 2. The data have been binned into 1 million year intervals and are split into (A) morphospecies originations, (B) morphospecies extinctions, (C) lineage originations and (D) lineage extinctions.

3.2.3 Eocene

The PETM was a short lived event and after approximately 170 kyr global temperatures fell and rapid increases in seafloor carbonate burial rates and biotic assemblage changes resulted in a situation very similar to the pre-excursion environment (Bowen *et al.*, 2006). During the early Eocene greenhouse conditions continued, the surface oceans were heavily stratified with a weak equator to pole thermal gradient (Pearson *et al.*, 2001). During this time macroperforate planktonic foraminifera assemblages from different geographic and latitudinal provinces were well mixed with tropical species found in the high latitudes (Boersma *et al*., 1987, 1998). Temperatures peaked during the Early Eocene Climatic Optimum (EECO) approximately 50 Ma then gradually declined for the remainder of the early Eocene (Figure 3.3). At this time the surface dwelling globular globoturborotalitids and planispiral pseudohastigerinids appeared. The muricates and parasubbotinids, already so successful in the late Paleocene, continued to thrive and diversify. A high turnover in muricate groups was accompanied by the appearance of several other new genera, *Turborotalia* in the surface waters, *Catapsydrax* in the sub-thermocline environment and *Pseudoglobigerinella* in areas of upwelling/high productivity (Figure 3.1.D).

The mid Eocene was a time of innovation and radiation; planktonic foraminiferal morphology became increasingly disparate with the reappearance of ornate groups, including the deep-dwelling clavate clavigerinellids and tubulospinose hantkeninids and the surface-dwelling, keel-spined *Astrorotalia*. The emergence of these ornate forms was approximately coincident with the appearance of the spinose surface-dwelling *Guembelitrioides* and globigerinathekids (Figure 3.1.D). After the EECO the temperature record for the middle Eocene shows a gradual global cooling punctuated by smaller magnitude thermal events (Figure 3.3). This period marked the peak of recorded macroperforate planktonic foraminiferal diversity with over 60 different morphospecies coexisting. Many of the morphological iterations, such as the acquisition of a keel and clavate chambers, are hypothesized to be associated with the invasion of new depth habitats (Norris, 1991; Coxall *et al*., 2007). This illustrates a successful period of clade expansion into new ecological niches during this time. Although many groups originated and were successful in the middle Eocene some significant genera and lineages became extinct. These included *Morozovella*, *Morozovelloides*, *Globanomalina*, *Igorina*, *Planoglobanomalina*, *Pseudoglobigerinella* and *Guembelitriodes* (Figure 3.1). It has been suggested that the extinction of the morozovellids and large acarininiids was not linked to climatic change but to increased surface water productivity and a demise of photosymbiotic relationships (Wade, 2004).

Global temperatures steadily declined during the late Eocene (Figure 3.3). Sub-surface polar waters decreased by 12˚C (Shackleton, 1984) but tropical sea-surface temperatures remained relatively stable (Pearson *et al*., 2007), which resulted in an enhancement of the latitudinal thermal gradient of the global oceans (Schmidt, Thierstein & Bollman, 2004). During this time there was a decline in macroperforate planktonic foraminifer diversity. Approximately 20 distinct morphospecies were lost from the sediment record between the peak in diversity during the middle Eocene and the end of the epoch 33.7 Ma.

3.2.4 Oligocene

The Eocene-Oligocene transition (E/O) was a period of intense global cooling with the development of a permanent ice-sheet on Antarctica and the initiation of the circum-Antarctic oceanic circulation. Benthic foraminiferal $\delta^{18}O$ values indicate that the Antarctic ice-sheet had a mass approximately 50% of the present day (Zachos *et al*., 2001). The transformation of global climate during the E/O appears to have had a profound effect upon the diversity of macroperforate planktonic foraminifera (Coxall & Pearson, 2007) and it was the most severe extinction event recorded since the K/Pg with standing morphospecies diversity dropping suddenly from over 40 to under 30. The deep dwelling ornate genera *Hantkenina* and *Clavigerinella* became extinct (Coxall & Pearson, 2007) but the loss of diversity is most notable in the warm surface-waters. Sub-thermocline genera remained unchanged which may suggest that deeper dwelling forms that were more naturally adapted to colder water environments were better able to transition the switch from greenhouse to icehouse conditions (Molina, Gonzalvo & Keller, 1993).

For the majority of the Oligocene epoch global temperatures and standing clade diversity remained relatively static with the number of recorded morphospecies staying between 30 – 35, and the number of lineages between 25-30 (Figures 3.2 and 3.3). The assemblage was composed of mixed-layer, spinose genera *Turborotalita*, *Globoturborotalita*, *Globigerinoides,* and *Globigerina* and the non-spinose *Turborotalia* and *Pseudohastigerina* (although *Pseudohastigerina* only survived into the early Oligocene). A number of new genera evolved during the Oligocene including non-spinose *Globoquadrina* and spinose *Globigerinella* that joined *Dentoglobigerina* in the thermocline. *Protentelloides* and *Protentella* exploited upwelling environments and several genera migrated between multiple depth horizons; *Turborotalia* was present in the mixed-layer and the sub-thermocline (although after 30.3 myr was only present in the mixed layer), *Paragloborotalia* was present in the mixed-layer and the thermocline and

Subbotina and *Dentoglobigerina* were present in the thermocline and sub-thermocline (Figure 3.1).

3.2.5 Miocene

Towards the end of the Oligocene global warming resulted in a reduction of Antarctic ice and latitudinal temperature gradients with surface and deep-waters temperatures higher than the Cenozoic average (Zachos *et al*., 1997). The reduced ice volume and warmer conditions continued until the Oligocene/Miocene boundary when another short but deep glacial maximum occurred (Zachos *et al*., 2001). Following this, a number of short glacial periods punctuated a general trend of global warming which culminated with the Mid-Miocene Climatic Optimum (MMCO) approximately 17 - 15 Ma. The warming of the climate during this period is suggested to be driven by tectonic and physical oceanographic changes rather than changes in CO_2 (Pagani, Arthur & Freeman, 1999). After the MMCO global temperatures started to decline and there was an associated increase in the latitudinal temperature gradient (Schmidt *et al*., 2004*a* & *b*).

During the early Miocene macroperforate planktonic foraminiferal diversity slowly increased. The increase in diversity was largely due to appearance of the important globorotaliid clade, which included the genera *Hirsutella*, *Menardella*, *Globorotalia*, *Globoconella* and *Truncorotalia*. The smooth-walled, non-spinose globorotaliids comprised a significant proportion of the thermocline and sub-thermocline diversity throughout the Miocene and remained successful through to the modern. The deeper water environments were also inhabited by the spinose genera *Globorotaloides*, *Orbulina*, *Beella* and *Globigerinella* and other non-spinose genera: *Fohsella*, *Pulleniatina*, *Sphaeroidinella*, *Sphaeroidinellopsis*, *Dentoglobigerina* and *Neogloboquadrina*. The diversity and success of the non-spinose forms in the thermocline and deeper was not reflected in the mixed layer and there is no isotopic evidence to suggest that any non-spinose forms inhabited the mixed layer during the Miocene.

A sharp increase in the number of morphospecies and lineages within the final two million years of the Miocene epoch led to levels comparable to those of the Middle Eocene with nearly 60 morphospecies and 40 lineages present at the Miocene/Pliocene boundary (see Figure 3.2). The diversity curves show that the diversification of macroperforate planktonic foraminifera during the Miocene occurred in two phases; the first, a gradual increase in diversity between 17-14 Ma, and the second much larger, abrupt expansion at Miocene/Pliocene transition 7-4 Ma (Figure 3.2). The first gradual radiation is coincident with the major frequency changes of the climate cycles during the MMCO (Kucera & Schönfeld, 2007) and the second pulse is suggested to be related to the closing of the Panama Seaway which thought to have resulted in increased oceanic provincialism (Kucera & Schönfeld, 2007). Both events may have increased environmental niche partitioning, which in turn, may have facilitated diversification.

3.2.6 Plio/Pleistocene

Temperatures continued to decline (Figure 3.3) across the Miocene/Pliocene boundary 5.3 Ma and the onset of glaciation in the northern hemisphere is suggested to have started between 2.95-2.82 Ma (Bartoli *et al*., 2005). Palaeoceanographic data from the North Atlantic support (Bartoli *et al*., 2005) previous models that propose the closure of the Panama Seaway (3.0-2.5 Ma) as the mechanism for intensification of the thermohaline circulation (Haug & Tiedemann, 1998). Between approximately 3.0-0.8 Ma northern hemisphere glaciation had a 41 kyr cyclicity which was driven by the Earths obliquity (Raymo & Nisancioglu, 2003). Deep water circulation changes are unlikely to have had significant effects upon the upper water column, particularly in the tropics, and these palaeoceanographic fluctuations did not appear to have significantly adverse effects on planktonic foraminiferal diversity which remained high, although the turnover in the assemblage does show higher than average rates of extinction and origination occurring during the last between 5-3 Ma particularly in the deeper dwelling forms (Figures 3.1 & 3.4).

There is a notable decline in diversity at the Plio-Pleistocene transition with the number of morphospecies reducing by nearly 20 over a one myr time period. Although the reduction in lineages is less severe there is still a notable loss in diversity on this curve signalling a true biological perturbation. The decline in diversity continued until the Mid Pleistocene transition when glacial cyclicity changed from 41 to 100 kyr in duration and sea-surface temperatures declined (Clarke *et al*., 2006), following this, diversity remained relatively constant. The disparity between the number of morphospecies and the number of lineages at this time is largely due to the taxonomic subdivision globorotaliid clade into many morphospecies that have now been grouped into distinct evolutionary lineages (see Chapter 2). During the Plio-Pleistocene transition the genus *Dentoglobigerina* became extinct but extinction principally affected the globorotaliids in the deeper waters when the number of species reduced from 35 to 16 (Figure 3.1 and 3.2).

3.2.7 Summary

Over the Cenozoic macroperforate planktonic foraminifera diversity peaked in two phases during the Middle Eocene and the Miocene/Pliocene boundary. The rise in diversity during the Paleogene had a much faster rate than the rise during the Neogene, taking approximately half the time to reach similar levels of diversity. The two peaks in diversity occur during very different global climate regimes but both periods are characterised by niche expansion. After the K/Pg extinction all but two species became extinct freeing up a wide range of habitats for colonisation, and as global temperatures rose throughout the Paleocene and early Eocene there was an increase in upper water-column stratification creating further niche partitioning. This was reflected by macroperforate planktonic foraminiferal diversity that expanded rapidly, particularly in the mixed layer. During the late Miocene and Pliocene there was a significant decrease in global temperatures and the onset of glaciation in the Northern Hemisphere, increased niche partitioning was facilitated by amplified oceanic provincialism due to tectonic and physical oceanographic changes (Kucera & Schönfeld, 2007). Diversity increase at this time was most expansive in deeper water environments, which may be explained by the better-adapted nature of sub-thermocline species to colder water environments. It is clear that changes in climate regimes exert a strong influence on diversity, for example; the high turnover rates during the PETM and extinctions during the E/O transition, but the variable response of the clade to changes in climate and oceanic structure is complicated and to disentangle the drivers of macroevolution in this group more sophisticated statistical analysis is required (see Section 3.4 Summary of "Interplay between Changing Climate and Species' Ecology Drives Macroevolutionary Dynamics").

The diversity curves of Figure 3.2 detail the changes in abundance of both evolutionary lineages and morphospecies of Cenozoic macroperforate planktonic foraminifera and includes the most up-to-date reviews of the taxonomy and phylogeny of this group.

Figure 3.5 demonstrates that the shape of these diversity curves are similar to some previous attempts to quantify planktonic foraminiferal diversity, although any attempts to compare these four curves must be done with caution as all of the curves represent different units and measurements of abundance. A and B of Figure 3.5 represent abundance at the species level whereas Figure 3.5 C and D are at the generic and sub-generic level. Also there is approximately a 30 year gap between the publication of earliest and most recent diversity curves. In this time there has been significant review of not only the taxonomy and phylogeny of the group but also the timescales against which the diversity curves are plotted. Nevertheless, all the curves show an increase in diversity from the K/Pg boundary through the Paleocene and into the middle Eocene, when major changes in oceanic stratification and global temperatures may have enhanced available niche space (Schmidt, *et al*. 2004*a*). A decline in diversity can be seen in A, B and D of Figure 3.5 at the E/O boundary but this is not reflected in C, this is probably due to timescale changes, a distinct shift in taxonomic practice between the present and the publication date of Figure 3.5 D and the use of genera rather than species. Figure 3.5 A, B and C continue to share the same broad patterns as they all reflect morphological disparity more faithfully by either using the Shannon-Weiner function (Figure 3.5 D) or morphospecies (Figure 3.5 A and B).

Iterated evolution of morphology (Norris 1991; Coxall *et al*., 2007) and ecology (Hart, 1980) has been hypothesised previously. However, mapping the morphogroup and ecogroup transitions onto the phylogenies (Figures 2.7 and 2.8, see also Electronic Appendix, Part B) illustrates the iterative pattern is more complicated than initially envisaged. For example, the development of a keel is hypothesized to be linked with the invasion of deeper water habitats (Hart, 1980) and keels have evolved in a number of different groups at various points during the Cenozoic. During the Paleogene *Globanomalina, Igorina, Morozovella* and *Turborotalia* developed keels and the Neogene genera *Fohsella, Globoconella, Globorotalia, Hirsutella, Menardella* and *Pulleniatina* included keeled forms. 32 of the species with keels lived in thermocline and sub-thermocline, but 15 (mostly the morozovellids) lived in the mixed layer, which is not entirely consistent with a depth habitat control. Repeated evolution of morphology and ecology seems to be spread across the clade as a whole, rather than one root stock giving rise to multiple lineages with iterated patterns occurring frequently, as initially envisaged by Cifelli (1969). Further phylogenetic and morphometric studies will be needed to investigate the macroevolutionary mechanisms that drive such patterns across much of this group.

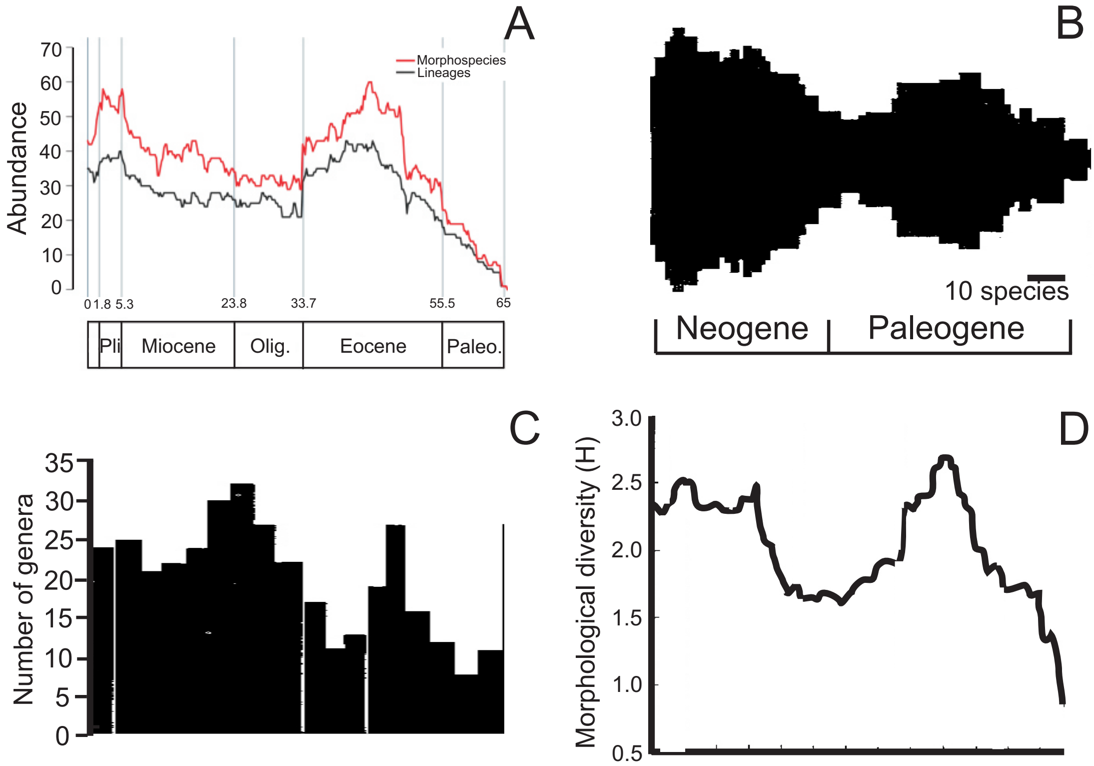


Figure 3.5 (A) Cenozoic macroperforate planktonic foraminifera morphospecies and lineage diversity of this work (B) a spindle diagram of Cenozoic planktonic foraminifera species diversity, diversity is calculated as the number of co-occurring species found at any time in a given foraminiferal zone, adapted from Norris (1991*a*) (C) Number of Cenozoic Globigerinina genera, adapted from Tappen & Loeblich (1988) and (D) Shannon-Weiner information function applied as a measure of morphological diversity, data are genera and sub-genera from Blow (1979), adapted from Arnold, Kelly & Parker (1995).

4. Testing Cope's rule

4.1 Introduction

Cope's rule states that along an evolutionary lineage descendants will be larger than their ancestors. As introduced in Section 1.1, the most reliable way of testing for Cope's rule is to identify and study a large number of direct ancestor-descendant relationships from a sufficiently large clade, over deep time (Gould, 1997). Due to the production of the evolutionary lineage phylogeny presented in Chapter 2 it is possible to identify these lines of descent for the entire Cenozoic macroperforate planktonic foraminifer clade, with only a few ambiguous relationships (as detailed in Section 2.3.1: A phylogeny of morphospecies).

An ideal situation would permit every lineage to be sampled, from every ocean basin for which there is material available due to the many environmental and biotic factors that can affect size. This level of sampling is not within the scope of this project; however Cope's rule can be still meaningfully tested with a significant proportion of the entire clade if chosen at random. Random selection of lineages would remove any of the psychological artefact that Gould (1997) suggested biased the findings of previous observations of phyletic size increase, nonetheless details of the limitations of this approach with respect to environmental and biotic variability are detailed in the discussion section of this chapter. It was initially envisaged that a third of the entire clade would be sampled to test for Cope's rule, and consequently 50 case studies were chosen at random from across the entire Cenozoic. The Cope's rule test in this chapter has been restricted to the Neogene only as the construction of the phylogenies that was necessary in order to conduct the random sampling took much longer than anticipated. The remainder of the case studies that are Paleogene in age are still in preparation and will be added to the Neogene data for publication when completed.

There is a wealth of pelagic microfossil material due to the many DSDP, ODP and IODP cores that have been collected from the deep sea during the last 60 years. A single gram of oceanic deep-sea sediment may contain as many as 10^2 - 10^5 individual planktonic foraminifer specimens (e.g. Barker *et al*., 2010). This abundance of material and a reliable phylogeny available for a 65 million year period make planktonic foraminifera a model group for testing Cope's rule.

4.2 Methods and materials

50 case studies were selected at random from the evolutionary lineage phylogeny presented in Chapter 2 and Aze *et al*. (2011). Each case study constituted an ancestor and two descendants (Fig. 4.1 A). In order to evaluate size changes that may be influenced by cladogenesis (before and after a speciation event) and anagenesis (along the length of an individual evolutionary lineage) each lineage was sampled twice (Fig. 4.1 B). The first appearance datum and last appearance datum (FAD and LAD respectively) of the randomly sampled lineages were discrete numeric values; consequently the sampling positions (Figure 4.1 x^a-x^f) were defined in millions of years e.g. 21.1 Ma. Specimens required for the size analysis were collected from deep-sea sediments and all samples analysed were carbonate microfossil oozes that were typically 95-98% planktonic foraminifera (Figure 4.2). In order to sample the correct point along a lineage using deep-sea sediments, correlations had to be made between the biozones of the lineage phylogeny timescale and the biozones that were used to date the sediments; these biozones commonly had different identifiers and lengths due to the continuing revision and improvement of planktonic foraminiferal biostratigraphy. Consequently samples were taken from an appropriate level within a biozone rather than an absolute point in time.

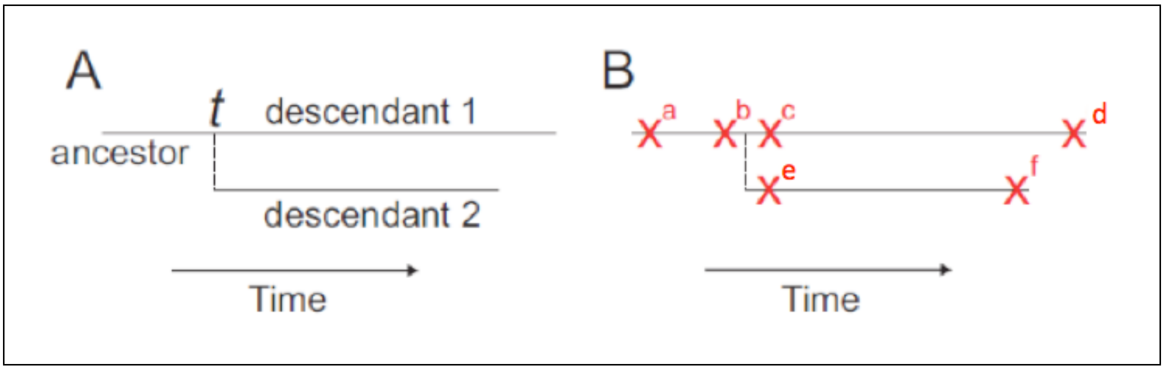


Figure 4.1 An illustration of one case study for testing Cope's rule (A) shows the relationships between the three lineages, the ancestor gives rise to a new species at time t and two Hennigian descendants are present after. (B) The symbol x^x illustrates where along these lineages samples were chosen for analysis. x^a and x^b sample near the start and end of the ancestral lineage, x^c and x^d near the start and end of descendant 1 and x^e and x^f near the start and end of descendant 2.

A combination of material from ODP Leg 144 (Marshall Islands, Pacific Ocean), ODP Leg 154 (Ceara Rise, western equatorial Atlantic Ocean), ODP Leg 183 (Kerguelen Plateau, Southern Ocean) and the GLOW cruise (south-west Indian Ocean) was sampled. All sediments had been washed over a 63µm sieve. The sediment was mixed, scooped randomly and scattered onto a microfossil picking tray. A previous comparsion of the mean size of the first 100 specimens collected through this method and through splitting the sample were found to be statistically indistinguishable (Electronic appendix, Part E) therefore the scooping method was employed as it facilitated picking a number of different species from the same sample that were present in distinctly different abundances.

Figure 4.2 An example of the sediment that was picked for the randomly selected lineages, note the dominance of planktonic foraminifera. Sample 872C 1H 6 58-60 from ODP Leg 144.

The first 100 specimens (see power analysis in Electronic Appendix - Part D) viewed under a light microscope were picked and mounted on a microfossil slide in a uniform orientation. The uniformity of specimen orientation was essential as the slides were then imaged using a Q-imaging QICAM Fast1394 camera mounted on an Olympus SZX7 microscope (Lens DF PL 1.5 x $^{-4}$ at magnification x 1.25). The images were then analyzed using Image Pro Plus version 6.2. The software can locate objects in an image in a number of different ways but most effective for planktonic foraminifera was a brightness threshold, where all objects of certain brightness are recognised and the perimeter identified, every image was checked to ensure that the outlines were representative of the actual foraminifer specimen outlines. A number of size and shape metrics were then generated from the outlined specimens, of principle interest for this analysis was the area function, which generates an area in microns (µm) by identifying the number of pixels incorporated into the outlined specimens (µm/pixels had previously been calibrated using a microfossil slide graticule).

4.2.1 Details of randomly selected case studies

The following section details the stratigraphic ranges and phylogenetic relationships of the randomly selected case studies for size analysis. Each case study summary features a detailed morphological description of the morphospecies that are contained within the lineages; the descriptions highlight the key architectural features of the tests that were used in delimiting the representative specimens of the lineages.

Case study 1: N300 'siphonifera': T304 'siphonifera': N301 'calida'

N300 'siphonifera' Range of lineage: 7.5 - 3.8 Ma

T304 'siphonifera' Range of lineage: 3.8 Ma - Recent

N301 'calida' Range of lineage: 3.8 - 0.3 Ma

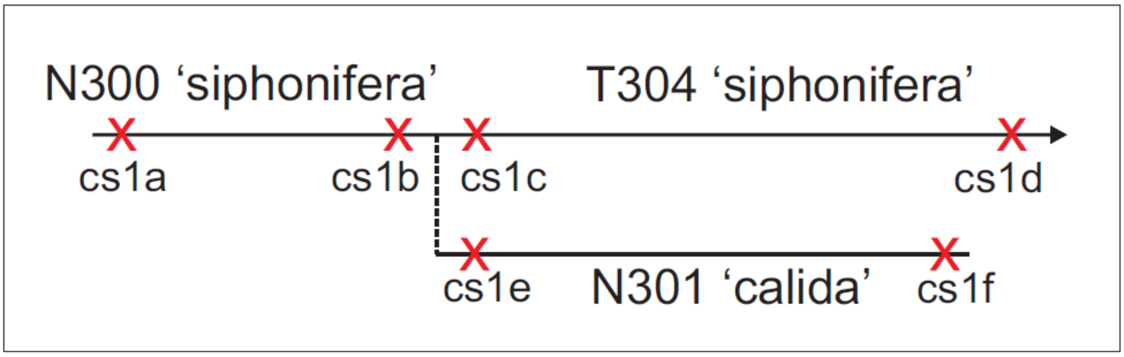


Figure 4.3 The evolutionary relationships between the Hennigian lineages N300'siphonifera', T304'siphonifera' and N301'calida' (Aze *et al.*, 2011). An arrow at the end of a lineage indicates that the lineage is extant. Below are detailed descriptions of the morphospecies within these lineages. cs1a – cs1f are the codes assigned to the populations that were sampled at the approximate points marked on the lineages.

Globigerinella siphonifera (BRADY)

DESCRIPTION

Type of wall: Spinose, hispid.

Test morphology: Low trochospiral in early stage, planispiral to nearly planispiral in adult stages, evolute. Chambers globular to subglobular with 5-6 present in final whorl. The test has a lobate equatorial periphery and rounded axial periphery. Aperture is a wide interiomarginal equatorial arch without a lip or rim.

DISTINGUISHING FEATURES - Globular nature of chambers and evolute, planispiral coiling habit.

STRATIGRAPHIC RANGE OF MORPHOSPECIES - 12.5Ma - Recent.

GEOGRAPHIC DISTRIBUTION - Tropical to warm subtropical.

STABLE ISOTOPE PALAEOBIOLOGY - Open-ocean thermocline (Pearson, Norris & Empson, 2001; Pearson & Shackleton, 1995).

Globigerinella calida (PARKER)

DESCRIPTION

Type of wall: Spinose, hispid.

Test morphology: Test low trochospiral. Test has lobulate equatorial periphery with a rounded axial periphery. Chambers are subglobular to ovate with 4-5 rapidly enlarging chambers in the final whorl. Aperture is an umbilical to extraumbilical low arch with narrow lip.

DISTINGUISHING FEATURES - Looks very similar to *G. siphonifera* but is more axially compressed and is not planispiral but instead has a low trochospiral coiling.

STRATIGRAPHIC RANGE OF MORPHOSPECIES - 4.4 Ma - Recent.

GEOGRAPHIC DISTRIBUTION - Low latitudes (Kennett & Srinivasan, 1983).

STABLE ISOTOPE PALAEOBIOLOGY – There is no stable isotope data available for this species but it was inferred to inhabit an open-ocean thermocline environment as other closely related morphospecies inhabit this environment (Aze *et al*., 2011), this concept applies to all morphospecies that are referenced to Aze *et al*. (2011) in the following descriptions.

DISCUSSION - Parker (1962) distinguishes G. *calida* from *Globigerina bulloides* (d'Orbigny) because of its increasing radially elongate chambers and from *G. siphonifera* because it is less involute. The distinction between the two forms for the purpose of this study has primarily been based on the planispiral nature of adult coiling and the more globular chamber shape exhibited by *G. siphonifera*. Juvenile forms of *G. siphonifera* are distinguished from *G. calida* by the absence of thicker opaque gametogenic calcite accompanied by a much smaller overall test size. *G. calida* is distinguished from *G. bulloides* due to the orientation of the aperture, being umbilical-extraumbilical rather than just umbilical and because of its very low trochospiral coiling.

Case study 2: N337 'connecta.trilobus', N339 'trilobus.sacculifer', T338 'bisphericus.sicanus.curva.glomerosa.circularis.universa'

N337 'connecta.trilobus' Range of lineage: 22.5 – 17.0 Ma

N339 'trilobus.sacculifer' Range of lineage: 17.0 - 3.3 Ma

T338 'bisphericus.sicanus.curva.glomerosa.circularis.universa' Range of lineage: 17.0 - Recent

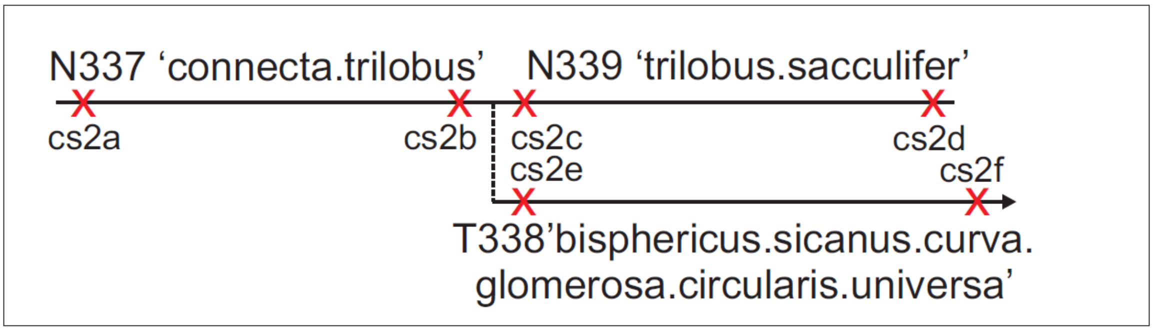


Figure 4.4 The evolutionary relationships between the Hennigian lineages N337 'connecta.trilobus', N339 'trilobus.sacculifer' and T338 'bisphericus.sicanus.curva.glomerosa.circularis.universa' (Aze *et al.*, 2011). An arrow at the end of a lineage indicates that the lineage is extant. Below are detailed descriptions of the morphospecies within these lineages. cs2a – cs2f are the codes assigned to the populations that were sampled at the approximate points marked on the lineages.

Globoturborotalita connecta JENKINS

DESCRIPTION

Type of wall: Spinose, hispid.

Test morphology: Low trochospiral, compact, equatorial periphery trilobate. Three chambers in final whorl that rapidly increase in size, the final chamber tends to overlap on to the earlier chambers. Aperture is a very low arch with a faint rim.

DISTINGUISHING FEATURES - The three chambers in the final whorl sit very close together with no clearly visible gaps between the chambers.

STRATIGRAPHIC RANGE OF MORPHOSPECIES - 23.0 - 16.83 Ma.

GEOGRAPHIC DISTRIBUTION - Low to middle latitudes (Kennett & Srinivasan, 1983).

STABLE ISOTOPE PALAEOBIOLOGY - Open-ocean mixed-layer with symbionts (Aze *et al.*, 2011).

Globigerinoides trilobus (REUSS)

DESCRIPTION

Type of wall: Spinose, cancellate.

Test morphology: Test low trochospiral. Test has lobulate equatorial periphery with a rounded axial periphery. Chambers are subglobular to ovate with 3 rapidly enlarging chambers in the final whorl. Aperture is an umbilical to extraumbilical low arch with narrow lip.

DISTINGUISHING FEATURES - Supplementary apertures on spiral side give a "loose" appearance to the chamber arrangement. Tests can be very large and are commonly some of the largest specimens in a sample. This species has a distinctive low arch primary aperture that distinguishes it from all other *Globigerinoides* species.

STRATIGRAPHIC RANGE OF MORPHOSPECIES - 22.10 - Recent.

GEOGRAPHIC DISTRIBUTION - Low latitudes (Kennett & Srinivasan, 1983).

STABLE ISOTOPE PALAEOBIOLOGY - Open-ocean thermocline with symbionts (Pearson & Shackleton, 1995; Pearson, Norris & Empson, 2001).

Globigerinoides sacculifer (BRADY)

DESCRIPTION

Type of wall: Spinose, cancellate.

Test morphology: Test low trochospiral. Chambers are subglobular to spherical except for final chamber that is sack like.

DISTINGUISHING FEATURES - Supplementary apertures on spiral side give a "loose" appearance to the chamber arrangement. Tests can be very large and are commonly some of the largest specimens in a sample. This species has a distinctive low arch primary aperture that distinguishes it from all other *Globigerinoides* species.

STRATIGRAPHIC RANGE OF MORPHOSPECIES - 22.10 - Recent.

GEOGRAPHIC DISTRIBUTION - Low latitudes (Kennett & Srinivasan, 1983).

STABLE ISOTOPE PALAEOBIOLOGY - Open-ocean thermocline with symbionts (Pearson & Shackleton, 1995; Pearson, Norris & Empson, 2001).

Globigernoides bisphericus TODD

DESCRIPTION

Type of wall: Spinose, cancellate.

Test morphology: Bilobate outline, has enveloping last chamber which almost completely hides the umbilicus, apertures are present along the suture between the last and earlier chambers though more apertures may remain open on the spire.

DISTINGUISHING FEATURES - Bilobate outline with final chamber forming half of the overall test size.

STRATIGRAPHIC RANGE OF MORPHOSPECIES - 18.2 - 15.6 Ma.

GEOGRAPHIC DISTRIBUTION - Low latitudes (Pearson & Shackleton, 1995).

STABLE ISOTOPE PALAEOBIOLOGY - Open-ocean mixed-layer tropical/subtropical, with symbionts (Keller, 1985; Pearson & Shackleton, 1995).

Praeorbulina sicanus DE STEFANI

DESCRIPTION

Type of wall: Spinose, cancellate.

Test morphology: Test is spherical to sub-spherical with apertures that form two to three narrow slits at the base of the final chamber.

DISTINGUISHING FEATURES - Spherical test and aperture arrangement.

STRATIGRAPHIC RANGE OF MORPHOSPECIES - 16.4 - 14.8 Ma.

GEOGRAPHIC DISTRIBUTION - Low to middle latitudes (Kennett & Srinivasan, 1983).

STABLE ISOTOPE PALAEOBIOLOGY - Open-ocean mixed-layer tropical/subtropical, with symbionts (Pearson, Shackleton & Hall, 1997; Pearson, Norris & Empson, 2001).

Praeorbulina curva (BLOW)

DESCRIPTION

Type of wall: Spinose, cancellate.

Test morphology: Spherical to sub-spherical with 4-8 small sutural supplementary apertures.

DISTINGUISHING FEATURES - Spherical test and aperture arrangement.

STRATIGRAPHIC RANGE OF MORPHOSPECIES - 15.9 - 15 Ma.

GEOGRAPHIC DISTRIBUTION - Low to mid latitudes (Kennett & Srinivasan, 1983).

STABLE ISOTOPE PALAEOBIOLOGY - Open ocean mixed layer tropical/subtropical, with symbionts (Pearson, Shackleton & Hall, 1997).

Praeorbulina glomerosa (BLOW)

DESCRIPTION

Type of wall: Spinose, cancellate.

Test morphology: Spherical to sub-spherical, apertures are several small cresentric and slit like openings along basal suture.

DISTINGUISHING FEATURES - Spherical test and aperture arrangement.

STRATIGRAPHIC RANGE OF MORPHOSPECIES - 15.8 - 15 Ma.

GEOGRAPHIC DISTRIBUTION - Low to mid latitudes (Kennett & Srinivasan, 1983).

STABLE ISOTOPE PALAEOBIOLOGY - Open-ocean mixed-layer tropical/subtropical, with symbionts (Pearson, Shackleton & Hall, 1997).

Praeorbulina circularis (BLOW)

DESCRIPTION

Type of wall: Spinose, cancellate.

Test morphology: Spherical to sub-spherical, numerous small apertures along the basal suture.

DISTINGUISHING FEATURES - Spherical test and aperture arrangement.

STRATIGRAPHIC RANGE OF MORPHOSPECIES - 14.9 - 15.7 Ma.

GEOGRAPHIC DISTRIBUTION - Low to middle latitudes (Kennett & Srinivasan, 1983).

STABLE ISOTOPE PALEOBIOLOGY - Open-ocean mixed-layer tropical/subtropical, with symbionts (Pearson, Shackleton & Hall, 1997).

Orbulina suturalis BRÖNNIMANN

DESCRIPTION

Type of wall: Spinose, hispid.

Test morphology: Almost spherical, final chamber not entirely enveloping earlier test, has areal supplementary apertures along sutures separating earlier and final chambers.

DISTINGUISHING FEATURES - Spherical test and aperture arrangement.

STRATIGRAPHIC RANGE OF MORPHOSPECIES - 15.1 - Recent.

GEOGRAPHIC DISTRIBUTION - Low to middle latitudes (Kennett & Srinivasan, 1983).

STABLE ISOTOPE PALAEOBIOLOGY - Open-ocean thermocline (Stewart, 2003).

Orbulina universa D'ORBIGNY

DESCRIPTION

Type of wall: Spinose, hispid.

Test morphology: Completely spherical with final chamber entirely enveloping earlier test, apertures are numerous small openings even distributed over the whole test.

DISTINGUISHING FEATURES - Completely spherical test.

STRATIGRAPHIC RANGE OF MORPHOSPECIES - 15.05 - Recent.

GEOGRAPHIC DISTRIBUTION - Low to high latitudes (Kennett & Srinivasan, 1983).

STABLE ISOTOPE PALAEOBIOLOGY - Open-ocean sub-thermocline (Vergnaud-Grazzini, 1976).

DISCUSSION - *G. connecta* was recognised as looking like a compacted version of *G. trilobus*, there is commonly a "loose" appearance of the chambers with *G. trilobus* with larger gaps visible on the umbilical side of the test. *G. connecta* has the same chamber arrangement as *G. trilobus* only the chambers sit much tighter together without visible gaps. *G. trilobus* specimens picked for this analysis ranged from large loosely coiled forms to more compact smaller forms but all with the same distinctive three chambers in the final whorl and low slit like aperture on umbilical side, and they were extremely abundant in the samples examined for this species. *G. sacculifer* specimens picked for this analysis ranged from large loosely coiled forms to more compact smaller forms but all with the same distinctive three chambers in the final whorl and low slit like aperture on umbilical side. *G. sacculifer* were very abundant and easy to identify owing to the distinctive final chamber.

Case study 3: N349 'decoraperta.tenella.rubescens', T350 'rubescens', T351 'tenella'

N349 'decoraperta.tenella.rubescens' Range of lineage: 14.3 - 2 Ma

T350 'rubescens' Range of lineage: 2 Ma – Recent

T351 'tenella' Range of lineage: 2 Ma - Recent

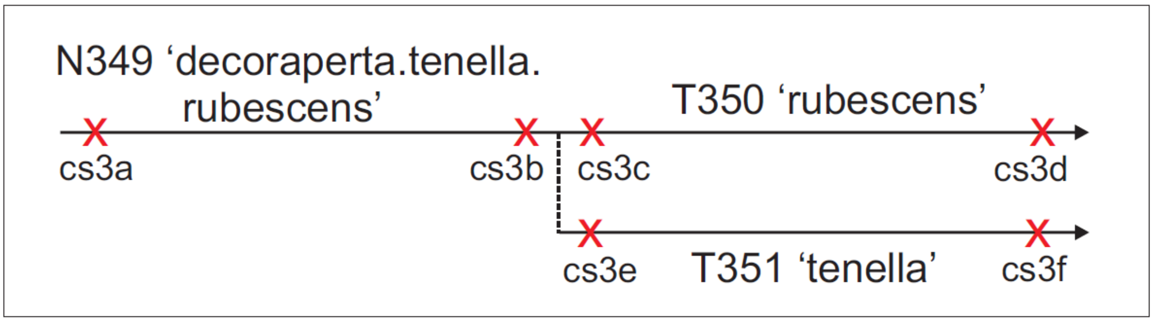


Figure 4.5 The evolutionary relationships between the Hennigian lineages N349 'decoraperta.tenella.rubescens', T350 'rubescens' and T351 'tenella' (Aze *et al*., 2011). An arrow at the end of a lineage indicates that the lineage is extant. Below are detailed descriptions of the morphospecies within these lineages. cs3a – cs3f are the codes assigned to the populations that were sampled at the approximate points marked on the lineages.

Globoturborotalita decoraperta TAKAYANAGI & SAITO

DESCRIPTION

Type of wall: Spinose, cancellate.

Test morphology: Compact, low to medium-high trochospiral. Periphery lobulate with spherical to subspherical chambers. Aperture is an interiomarginal umbilical large semicircular opening bordered by a rim.

DISTINGUISHING FEATURES - Large aperture and nature of coiling.

STRATIGRAPHIC RANGE OF MORPHOSPECIES - 15 - 2 Ma.

GEOGRAPHIC DISTRIBUTION - Low latitudes (Kennett & Srinivasan, 1983).

STABLE ISOTOPE PALAEOBIOLOGY - Open-ocean mixed-layer tropical/subtropical, without symbionts (Aze *et al*., 2011).

Globoturborotalita tenella PARKER

DESCRIPTION

Type of wall: Spinose, cancellate.

Test morphology: Small, low trochospiral, chambers spherical. Primary aperture umbilical large almost circular opening with distinct rim, small supplementary aperture on spiral side

DISTINGUISHING FEATURES - Test is very small, with bulbous chambers. Morphologically this species is very similar to *G. rubescens* other than having a small supplementary aperture on the spiral side.

STRATIGRAPHIC RANGE OF MORPHOSPECIES - 2.4 Ma - Recent.

GEOGRAPHIC DISTRIBUTION - Low latitudes (Kennett & Srinivasan, 1983).

STABLE ISOTOPE PALAEOBIOLOGY - Open-ocean mixed-layer tropical/subtropical, without symbionts (Aze *et al*., 2011).

Globoturborotalita rubescens HOFKER

DESCRIPTION

Type of wall: Spinose, cancellate.

Test morphology: Small, trochospiral, equatorial periphery lobulate, chambers spherical to sub-spherical. Aperture is a small rounded umbilical opening bordered by a distinct rim.

DISTINGUISHING FEATURES - Very small test size and coarsely cancellate wall. In modern samples specimens are often a pinkish red colour.

STRATIGRAPHIC RANGE OF MORPHOSPECIES - 3.6 Ma - Recent.

GEOGRAPHIC DISTRIBUTION - Low latitudes (Kennett & Srinivasan, 1983).

STABLE ISOTOPE PALAEOBIOLOGY - Open-ocean mixed-layer tropical/subtropical, without symbionts (Aze *et al*., 2011).

DISCUSSION – *G. decoraperta* is distinguished from *G. rubescens* by its larger size, less coarsely cancellate wall texture and smaller aperture. It differs from *G. woodi* by have a higher spired coiling. *G. rubescens* was generally very abundant in the samples that were analysed for it. Identification was often made easier by the red staining which was not apparent in any other species in these samples, although not all specimens of this species exhibited the staining. *G. tenella* was much less abundant than *G. rubescens* and took much more time to collect as all specimens need to be manipulated onto their umbilical side in order to see the supplementary aperture. This aperture was often not visible until the sampled had dried having been in contact with a wetted paintbrush and so each specimen required more time than most other species to collect.

Case study 4: N354 'woodi', T356 'woodi.apertura', T355 'nepenthes'

Range of lineage: N354 'woodi' 12.1 - 11.5 Ma

Range of lineage: T356 'woodi.apertura' 11.5 - 1.3 Ma

Range of lineage: T355 'nepenthes' 11.5 - 4.3 Ma

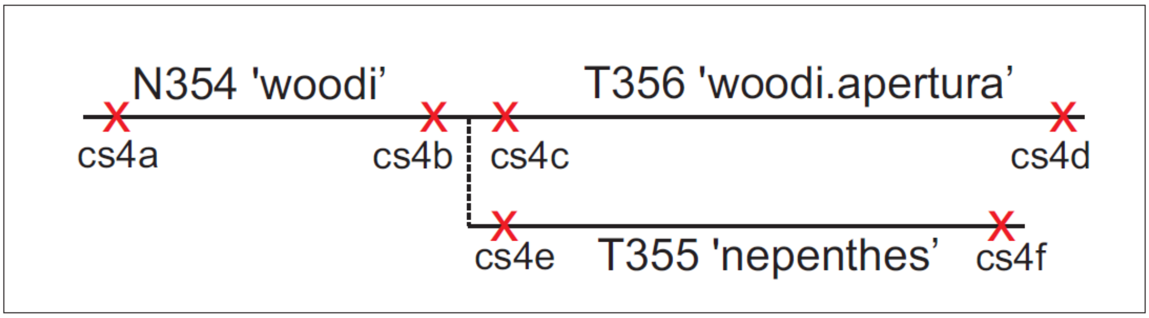


Figure 4.6 The evolutionary relationships between the Hennigian lineages N354 'woodi', T356 'woodi.apertura' and T355 'nepenthes' (Aze *et al*., 2011). Below are detailed Descriptions of the morphospecies within these lineages. cs4a – cs4f are the codes assigned to the populations that were sampled at the approximate points marked on the lineages.

Globoturborotalita woodi JENKINS

DESCRIPTION

Type of wall: Spinose, cancellate.

Test morphology: Low trochospiral, equatorial periphery trilobate to nearly quadrilobate, chambers spherical to sub-spherical, aperture is an interiomarginal umbilical high arch bordered by a thick rim.

DISTINGUISHING FEATURES - A trilobate to nearly quadrilobate outline with a central high arched symmetrical aperture.

STRATIGRAPHIC RANGE OF MORPHOSPECIES - 30.6 - 2.4 Ma.

GEOGRAPHIC DISTRIBUTION - Low to middle latitudes (Kennett & Srinivasan, 1983)

STABLE ISOTOPE PALAEOBIOLOGY – Open-ocean mixed-layer with symbionts (Pearson, Shackleton & Hall, 1997; Pearson *et al*., 2007).

Globoturborotalita apertura CUSHMAN

DESCRIPTION

Type of wall: Spinose, cancellate.

Test morphology: Low trochospiral, chambers spherical to sub-spherical, aperture is a very large umbilical semi-circular arch with distinct rim.

DISTINGUISHING FEATURES - Very large open, central aperture with distinct rim.

STRATIGRAPHIC RANGE OF MORPHOSPECIES - 10.9 - 1.3 Ma.

GEOGRAPHIC DISTRIBUTION - Low to middle latitudes (Kennett & Srinivasan, 1983).

STABLE ISOTOPE PALAEOBIOLOGY - Open-ocean mixed-layer without symbionts (Aze *et al*., 2011).

Globoturborotalita nepenthes TODD

DESCRIPTION

Type of wall: Spinose, cancellate.

Test morphology: Compactly coiled except for last formed protruding chamber, low to high spire broad arch at the umbilical edge of the final chamber bordered by thickened rim.

DISTINGUISHING FEATURES - The test has a strongly ovate peripheral outline with a very distinctive final chamber that looks like an upside down pitcher plant.

STRATIGRAPHIC RANGE OF MORPHOSPECIES - 12.1 - 4.3 Ma.

GEOGRAPHIC DISTRIBUTION - Low latitudes (Kennett & Srinivasan, 1983).

STABLE ISOTOPE PALAEOBIOLOGY - Open-ocean mixed-layer without symbionts (Stewart, 2003).

DISCUSSION - *G. apertura* is distinguishable from *G. woodi* only by the markedly larger aperture, but as both are regarded as the same biological lineage specimens that had large apertures and those that did not were both picked. *G. nepenthes* was not a particularly abundant species but due to the highly distinctive chamber arrangement, in particular the scoop-like final chamber, this species was easily recognised in the sediment.

Case study 5: N342 'woodi', N344 'woodi', T343 'parawoodi'

Range of lineage: N342 'woodi' - 22.5 - 21.1 Ma
Range of lineage: N344 'woodi' - 21.1 - 16.4 Ma
Range of lineage: T343 'parawoodi' - 21.1 - 17.3 Ma

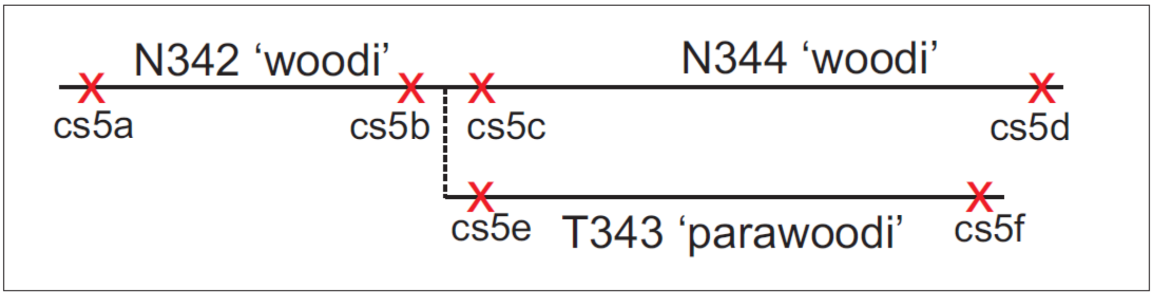


Figure 4.7 The evolutionary relationships between the Hennigian lineages N342 'woodi', N344 'woodi' and T343 'parawoodi' (Aze *et al*., 2011). Below are detailed descriptions of the morphospecies within these lineages. cs5a – cs5f are the codes assigned to the populations that were sampled at the approximate points marked on the lineages.

Globoturborotalita woodi JENKINS
See Section 4.3.4

Globigerinoides parawoodi KELLER
DESCRIPTION
Type of wall: Spinose, cancellate.
Test morphology: Low trochospiral, chambers spherical to ovate, primary aperture interiomarginal, umbilical, medium sized arch with supplementary sutural apertures on spiral side.

DISTINGUISHING FEATURES – *G. parawoodi* looks just like *G. woodi* only it has a supplementary aperture on the spiral side.

STRATIGRAPHIC RANGE OF MORPHOSPECIES - 16.4 - 21.5 Ma.

GEOGRAPHIC DISTRIBUTION - Middle latitudes (Kennett & Srninvasan, 1983).

STABLE ISOTOPE PALAEOBIOLOGY - Open-ocean mixed-layer with symbionts (Keller, 1985).

DISCUSSION - *G. woodi* is incorrectly described in Kennett & Srinivasan (1983) as symmetrically quadrilobate however if the holotype images are referred to, *G. woodi* is trilobate to slightly quadrilobate. Initially Kennett & Srinivasan (1983) was used as the taxonomic guide for this case study the populations that were originally collected were found to be incorrect when compared to the holotype image and description. When re-sampled with the correct taxonomic information only the ancestor-descendant populations from N342 'woodi' could be found in the sediments available. This lineage will be added to the list of remaining Paleogene lineages and will be re-sampled at a later date.

Case study 6: N64 'truncatulinoides.excelsa.pachytheca', T66 'truncatulinoides.excelsa.pachytheca', T65 'cavernula'.

Range of lineage: N64 'truncatulinoides.excelsa.pachytheca' - 1.4 - 0.8 Ma

Range of lineage: T66 'truncatulinoides.excelsa.pachytheca' - 0.8 - Recent

Range of lineage: T65 'cavernula' - 0.8 - Recent

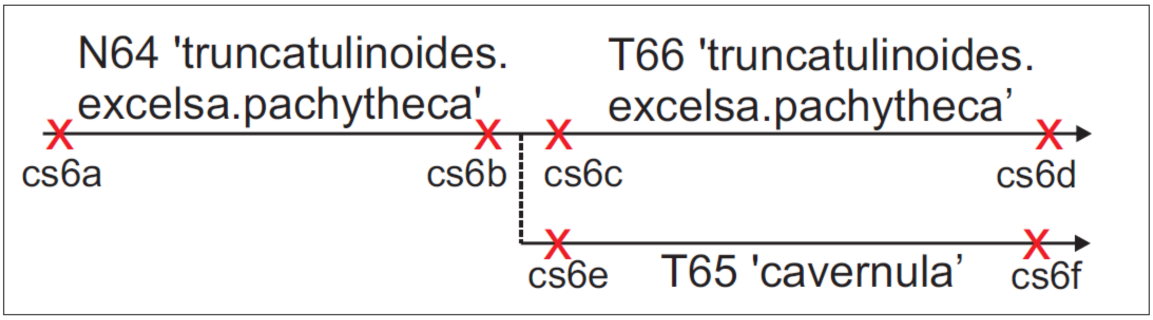


Figure 4.8 The evolutionary relationships between the Hennigian lineages N64 'truncatulinoides.excelsa.pachytheca', T66 'truncatulinoides.excelsa.pachytheca' and T65 'cavernula' (Aze *et al.*, 2011). An arrow at the end of a lineage indicates that the lineage is extant. Below are detailed descriptions of the morphospecies within these lineages. cs6a – cs6f are the codes assigned to the populations that were sampled at the approximate points marked on the lineages.

Truncorotalia truncatulinoides (D'ORBIGNY)

DESCRIPTION

Type of wall: Non-spinose, smooth.

Test morphology: Low trochospiral, strongly umbilico-convex with distinct keel Interiomarginal umbilical, aperture is an extraumbilical low arch bordered by lip.

DISTINGUISHING FEATURES - Flat on spiral side, heavily keeled periphery with high conical umbilical side.

STRATIGRAPHIC RANGE OF MORPHOSPECIES - 1.9 Ma - Recent.

GEOGRAPHIC DISTRIBUTION - Low latitudes (Kennett & Srinivasan, 1983).

STABLE ISOTOPE PALAEOBIOLOGY - Open-ocean sub-thermocline (Vergnaud-Grazzini, 1976; Shackleton & Vincent, 1978)

Truncorotalia excelsa SPROVIERI, RUGGIERI & UNTI.

DESCRIPTION

Type of wall: Non-spinose, smooth.

Test morphology: Ventroconical, steep conical umbilical side, spiral side flat to slightly concave, acutely keeled, heavily pustulate test. Aperture is an interiomarginal umbilical-extraumbilical low arched slit.

DISTINGUISHING FEATURES - The acute peripheral keel and pustulose test wall.

STRATIGRAPHIC RANGE OF MORPHOSPECIES - 1.85 Ma - Recent.

GEOGRAPHIC DISTRIBUTION - Low to middle latitudes (Kennett & Srinivasan, 1983).

STABLE ISOTOPE PALAEOBIOLOGY - Open ocean sub-thermocline Aze *et al*., 2011).

Truncorotalia pachytheca BLOW

DESCRIPTION

Type of wall: Non-spinose, smooth.

Test morphology: As *T. truncatulinoides* but with more rounded chambers and less conical umbilical side, aperture is an interiomarginal umbilical-extraumbilical low arch bordered by lip.

DISTINGUISHING FEATURES – A morphological variant of *T. truncatulinoides*, this morphotypes has a more acute peripheral keel, more open umbilicus and fewer pustules on the surface. The morphospecies comprises specimens with a thick calcite crust and so is probably an ecophenotype of the *T. truncatulinoides* biospecies.

STRATIGRAPHIC RANGE OF MORPHOSPECIES - 1.8 Ma - Recent.

GEOGRAPHIC DISTRIBUTION – Low latitudes (Kennett & Srinivasan, 1983).

STABLE ISOTOPE PALAEOBIOLOGY – Open-ocean sub-thermocline (Aze *et al*., 2011)

Truncorotalia cavernula BÉ

DESCRIPTION

Type of wall: Non-spinose, smooth.

Test morphology: Small, very low trochospiral, spiral side almost flat, umbilical side distinctly convex. Aperture is an interiomarginal umbilical-extraumbilical high rounded arch with a distinct rim.

DISTINGUISHING FEATURES – This species was never found.

STRATIGRAPHIC RANGE OF MORPHOSPECIES - 0.9 Ma - Recent.

GEOGRAPHIC DISTRIBUTION - Low Latitudes (Kennett and Srinivasan, 1983)

STABLE ISOTOPE PALAEOBIOLOGY - Open-ocean sub-thermocline (Stewart, 2003).

DISCUSSION – The lineage 'truncatulinoides.excelsa.pachytheca' allows all morphological variants to be assumed as one and specimens of this lineage were typically very abundant in the samples that were picked. *T. cavernula* was not found in any samples analyzed and there appears to be some taxonomic confusion regarding this species. Inspection of the original holotype illustration (Bé, 1967) is not congruent with the SEM image or taxonomic description contained in Kennett & Srinivasan, (1983). Kennett & Srinivasan, (1983) was the reference text for the phylogenetic relationships between *Truncorotalia truncatulinoides* and *Truncorotalia cavernula*, but based on the morphology of the holotype this phylogenetic affinity is probably incorrect and Stewart (2003) regards *T. cavernula* as a hirsutellid. Sediments from three different ocean basins were searched for *T. cavernula*, but no specimens were found. The relationship between *T. truncatulinoides* and *T. cavernula* requires further phylogenetic and morphometric investigation before it can be re-sampled for Cope's rule.

Case study 7: N157 'continuosa.acostaensis', N160 'continuosa.acostaensis', T158 'humerosa.dutertrei'

Range of lineage: N157 'continuosa.acostaensis' - 10.8 - 8.0 Ma

Range of lineage: N160 'continuosa.acostaensis' - 8.0 - 7.5 Ma

Range of lineage: T158 'humerosa.dutertrei' - 8.0 - Recent

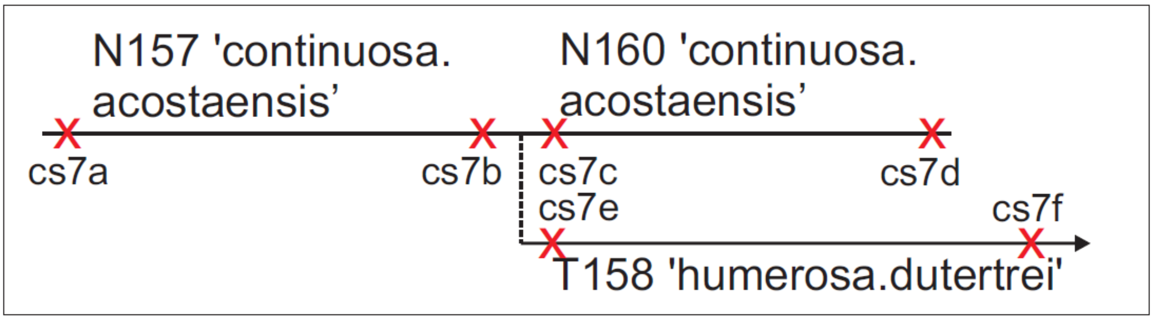


Figure 4.9 The evolutionary relationships between the Hennigian lineages N157 'continuosa.acostaensis', N160 'continuosa.acostaensis' and T158 'humerosa.dutertrei' (Aze *et al.*, 2011). An arrow at the end of a lineage indicates that the lineage is extant. Below are detailed descriptions of the morphospecies within these lineages. cs7a – cs7f are the codes assigned to the populations that were sampled at the approximate points marked on the lineages.

Neogloboquadrina continuosa (BLOW)

DESCRIPTION

Type of wall: Non-spinose, cancellate.

Test morphology: Low trochospiral, equatorial periphery lobulate, chambers sub-spherical to ovate, aperture is an interiomarginal, umbilical-extraumbilical low arch bordered by a distinct rim.

DISTINGUISHING FEATURES - Only four chambers are visible in final whorl on the umbilical side and distinct apertural rim.

STRATIGRAPHIC RANGE OF MORPHOSPECIES - 23.2 - 7.8 Ma

GEOGRAPHIC DISTRIBUTION - Low latitudes (Kennett & Srinivasan, 1983).

STABLE ISOTOPE PALAEOBIOLOGY - Open-ocean thermocline (Keller, 1985).

Neogloboquadrina acostaensis (BLOW)

DESCRIPTION

Type of wall: Non-spinose, cancellate.

Test morphology: Low trochospiral, equatorial periphery strongly lobulate Interiomarginal umbilical-extraumbilical. Aperture is a low arch with distinct rim or plate covering much of the umbilicus.

DISTINGUISHING FEATURES – Plate-like lip over the aperture, although this is often not present as it is observed to be easily damaged and knocked off. Other distinguishing features are the number and arrangement of the chambers, with only four typically visible in the final whorl on the umbilical side.

STRATIGRAPHIC RANGE OF MORPHOSPECIES - 10.9 - 1.7 Ma.

GEOGRAPHIC DISTRIBUTION - Low latitudes (Kennett & Srinivasan, 1983)

STABLE ISOTOPE PALAEOBIOLOGY - Open-ocean thermocline (Pearson & Shackleton, 1995).

Neogloboquadrina humerosa (TAKAYANAGI & SAITO)

DESCRIPTION

Type of wall: Non-spinose, cancellate.

Test morphology: Low trochospiral, equatorial periphery lobulate, chambers ovate. Aperture is an interiomarginal umbilical-extraumbilical low to medium arch with distinct rim.

DISTINGUISHING FEATURES - Six to seven chambers in the final whorl and the extraumbilical lean of the aperture.

STRATIGRAPHIC RANGE OF MORPHOSPECIES - 9.7 - 1.6 Ma.

GEOGRAPHIC DISTRIBUTION - Low latitudes (Kennett & Srinivasan, 1983).

STABLE ISOTOPE PALAEOBIOLOGY - Open-ocean thermocline (Aze *et al*., 2011).

Neogloboquadrina dutertrei (D'ORBIGNY)

DESCRIPTION

Type of wall: Non-spinose, cancellate.

Test morphology: Trochospiral, globose, spiral side flat to slightly convex, aperture is an umbilical-extraumbilical broad deep opening with tooth-like umbilical plates often present.

DISTINGUISHING FEATURES - Six to seven chambers in the final whorl, final chamber is slightly out line with the final whorl making the test appear to have a higher spire. Also may have tooth like projection from the final chamber covering the aperture, although this is broken off in some instances.

STRATIGRAPHIC RANGE OF MORPHOSPECIES - 6.9 - Recent.

GEOGRAPHIC DISTRIBUTION - Low latitudes (Kennett & Srinivasan, 1983).

STABLE ISOTOPE PALAEOBIOLOGY - Open-ocean thermocline (Kahn, 1979; Shackleton & Vincent, 1978).

DISCUSSION – The neogloboquadrinids were generally abundant and their coarsely cancellate wall texture aided identification. Distinctions between the lineages 'continuosa.acostaensis' and 'humerosa.dutertrei' were principally based upon the number of chambers in the final whorl with the former lineage typically having four and the latter having six to seven.

Case study 8: N35 'limbata', N37 'limbata', T36 'multicamerata'

Range of lineage: N35 'limbata' - 10.3 - 6.5 Ma

Range of lineage: N37 'limbata' - 6.5 - 5.7 Ma

Range of lineage: T36 'multicamerata' 6.5 - 2.2 Ma

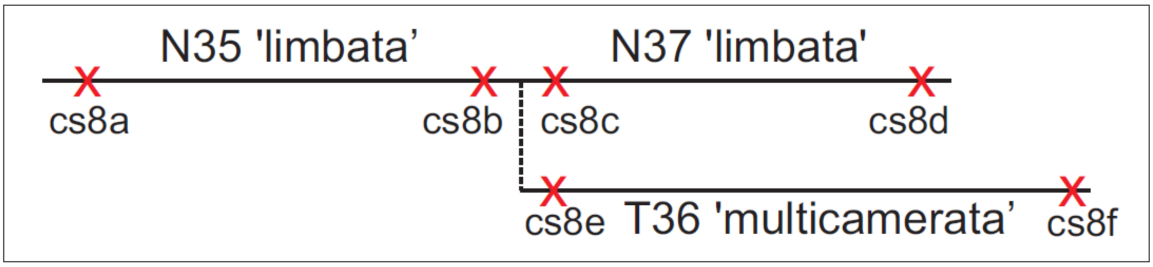


Figure 4.10 The evolutionary relationships between the Hennigian lineages N35 'limbata', N37 'limbata' and T36 'multicamerata' (Aze *et al*., 2011). An arrow at the end of a lineage indicates that the lineage is extant. Below are detailed descriptions of the morphospecies within these lineages. cs8a – cs8f are the codes assigned to the populations that were sampled at the approximate points marked on the lineages.

Menardella limbata (FORNASINI)

DESCRIPTION

Type of wall: Non-spinose, smooth.

Test morphology: Lenticular, low trochospiral, prominent keel and densely perforate surface, aperture is an interiomarginal umbilical-extraumbilical low-arched slit with lip.

DISTINGUISHING FEATURES - This species has six to eight chambers in its final whorl and the limbate sutures.

STRATIGRAPHIC RANGE OF MORPHOSPECIES - 11.4 - 2.3 Ma.

GEOGRAPHIC DISTRIBUTION - Low latitudes (Kennett & Srinivasan, 1983).

STABLE ISOTOPE PALAEOBIOLOGY - Open- ocean thermocline (Aze *et al*., 2011).

Menardella multicamerata CUSHMAN & JARVIS

DESCRIPTION

Type of wall: Non-spinose, smooth

Test morphology: Lenticular, low trochospiral, prominent keel and densely perforate surface, aperture is an interiomarginal umbilical-extraumbilical low-arched slit with distinct lip

DISTINGUISHING FEATURES - This species has eight to ten chambers in its final whorl.

STRATIGRAPHIC RANGE OF MORPHOSPECIES - 6.5 - 2.2 Ma.

GEOGRAPHIC DISTRIBUTION - Low latitudes (Kennett & Srinivasan, 1983).

STABLE ISOTOPE PALAEOBIOLOGY - Open- ocean thermocline (Stewart, 2003).

DISCUSSION - The two species were distinguished from each other by the number of chambers present on the final whorl, with *M. limbata* having six to eight and *M. multicamerata* having eight to ten. The limbate nature of the sutures on the spiral side of *M. limbata* was used to delimit specimens when both had eight chambers.

Case study 9: N362 'subquadratus', N332 'subquadratus', N327 'altiapertura.obliquus'

Range of lineage: N362 'subquadratus' - 22.7 - 21.0 Ma

Range of lineage: N332 'subquadratus' - 21.0 - 17.5 Ma

Range of lineage: N327 'altiapertura.obliquus' - 21.0 - 7.5 Ma

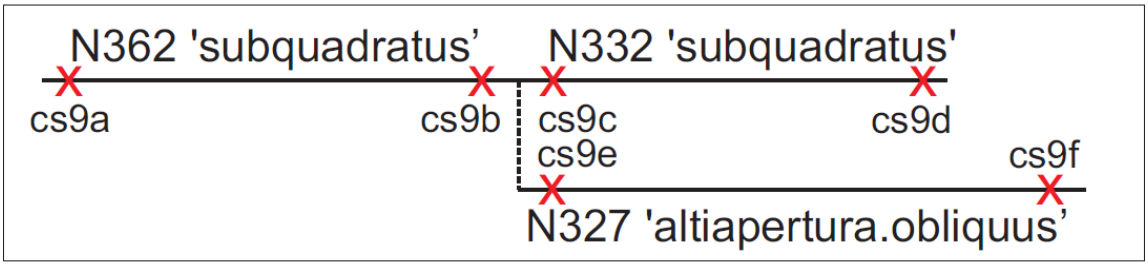


Figure 4.11 The evolutionary relationships between the Hennigian lineages N362 'subquadratus', N332 'subquadratus' and N327 'altiapertura.obliquus' (Aze *et al*., 2011). An arrow at the end of a lineage indicates that the lineage is extant. Below are detailed descriptions of the morphospecies within these lineages. cs9a – cs9f are the codes assigned to the populations that were sampled at the approximate points marked on the lineages.

Globigerinoides subquadratus BRÖNNIMANN

DESCRIPTION

Type of wall: Spinose, cancellate.

Test morphology: Trochospiral, outline subquadrate, chambers spherical to subspherical. Primary aperture interiomarginal, umbilical, wide arch with distinct rim. Supplementary sutural apertures on spiral side.

DISTINGUISHING FEATURES - The subquadrate and symmetrical appearance, particularly on the spiral side.

STRATIGRAPHIC RANGE OF MORPHOSPECIES - 23.0 - 10.8 Ma.

GEOGRAPHIC DISTRIBUTION - Low latitudes (Kennett & Srinivasan, 1983).

STABLE ISOTOPE PALAEOBIOLOGY - Open-ocean mixed-layer, with symbionts (Keller, 1985).

Globigerinoides altiapertura BOLLI

DESCRIPTION

Type of wall: Spinose, cancellate.

Test morphology: Low trochospiral, with an interiomarginal primary aperture that is an umbilical, high distinct arch, one supplementary sutural aperture is present opposite the primary aperture.

DISTINGUISHING FEATURES - The large high aperture.

STRATIGRAPHIC RANGE OF MORPHOSPECIES - 22.0 - 16.4 Ma.

GEOGRAPHIC DISTRIBUTION - Low latitudes (Kennett & Srinivasan, 1983).

STABLE ISOTOPE PALAEOBIOLOGY - Open-ocean mixed-layer, with symbionts (Keller, 1985).

Globigerinoides obliquus BOLLI

DESCRIPTION

Type of wall: Spinose, cancellate.

Test morphology: Trochospiral, chambers spherical except final chamber which is compressed in a lateral oblique manner. Primary aperture is an interiomarginal, umbilical, high, wide arch. Supplementary sutural apertures on spiral.

DISTINGUISHING FEATURES - Oblique squashed appearance of the final chamber.

STRATIGRAPHIC RANGE OF MORPHOSPECIES - 21.9 - 1.3 Ma.

GEOGRAPHIC DISTRIBUTION - Low latitudes (Kennett & Srinivasan, 1983).

STABLE ISOTOPE PALAEOBIOLOGY - Open-ocean mixed-layer, with symbionts (Keller, 1985; Pearson, Norris & Empson, 2001).

DISCUSSION - *G. subquadratus* was distinguished from *G. ruber* by it more quadrate outline and the symmetrical appearance of the spiral side. *G. altiapertura* and *G. obliquus* were easily identified due to their distinctive morphology, the former being high spired with a large open aperture and the latter having an obliquely "squashed-looking" final chamber.

Case study 10: N334 'subquadratus.diminutus', T360 'subquadratus', T335 'ruber.seiglei'

Range of lineage: N334 'subquadratus.diminutus' - 17.5 - 15.1 Ma.
Range of lineage: T360 'subquadratus' - 15.1 - 10.8 Ma.
Range of lineage: T335 'ruber.seiglei' - 15.1 - Recent.

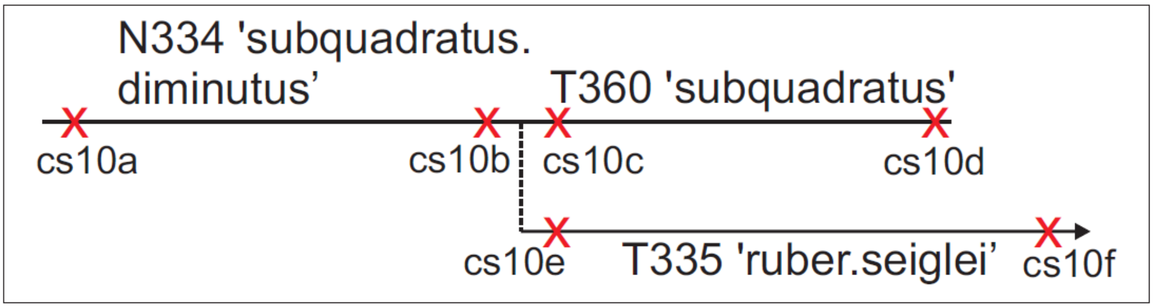


Figure 4.12 The evolutionary relationships between the Hennigian lineages N334 'subquadratus.diminutus', T360 'subquadratus' - 15.1 - 10.8 Ma and T335 'ruber.seiglei' (Aze *et al*., 2011). An arrow at the end of a lineage indicates that the lineage is extant. Below are detailed descriptions of the morphospecies within these lineages. cs10a – cs10f are the codes assigned to the populations that were sampled at the approximate points marked on the lineages.

Globigerinoides subquaratus BRÖNNIMANN
See Section 4.3.9.

Globigerinoides diminutus BOLLI
DESCRIPTION
Type of wall: Spinose, cancellate.
Test morphology: Small, trochospiral, equatorial periphery subquadrate. Primary aperture is an interiomarginal, umbilical, small circular symmetrical arch. Supplementary sutural apertures are present on the spiral side.
DISTINGUISHING FEATURES - Small size and subquadrate outline.
STRATIGRAPHIC RANGE OF MORPHOSPECIES - 17.3 -14.8 Ma.
GEOGRAPHIC DISTRIBUTION - Low latitudes (Kennett & Srinivasan, 1983).

STABLE ISOTOPE PALAEOBIOLOGY - Open-ocean mixed-layer, with symbionts (Keller, 1985).

Globigerinoides ruber (D'ORBIGNY)

DESCRIPTION

Type of wall: Spinose, cancellate.

Test morphology: Low to high trochospiral, subspherical chambers Primary aperture is an interiomarginal, umbilical, wide arch with rim. Supplementary sutural apertures are present on the spiral side.

DISTINGUISHING FEATURES - The high arched aperture that sits directly over the suture of the two previous chambers.

STRATIGRAPHIC RANGE OF MORPHOSPECIES - 15.1 - Recent.

GEOGRAPHIC DISTRIBUTION - Low latitudes (Kennett & Srinivasan, 1983).

STABLE ISOTOPE PALAEOBIOLOGY - Open-ocean mixed-layer, with symbionts (Keller, 1985; Pearson & Shackleton, 1995; Pearson, Norris & Empson, 2001).

Globigerinoides seigeli BERMUDEZ & BOLLI

DESCRIPTION

Type of wall: Spinose, cancellate.

Test morphology: Large, medium to high trochospiral, subquadrate outline. Primary aperture is an interiomarginal umbilical wide arch with rim. Supplementary sutural apertures are present on the spiral side.

DISTINGUISHING FEATURES – An obliquely squashed-looking morphological variant of *G. ruber*.

STRATIGRAPHIC RANGE OF MORPHOSPECIES - 9.6 - 5.3 Ma.

GEOGRAPHIC DISTRIBUTION - Low latitudes (Kennett & Srinivasan, 1983).

STABLE ISOTOPE PALAEOBIOLOGY - Open-ocean mixed-layer, with symbionts (Keller, 1985).

DISCUSSION – *G. ruber* and *G. subquadratus* were distinguished from one another on the basis of the quadrate appearance of the test outline and the symmetry of the spiral side which was more bilaterally symmetrical in *G. subquadratus*.

Case study 11: N344 'woodi', N348 'woodi', N348 'disjuncta.seminulina'

Range of lineage: N344 'woodi' - 21.1 - 17.3 Ma

Range of lineage: N348 'woodi' - 17.3 - 14.3 Ma

Range of lineage: N348 'disjuncta.seminulina' - 17.3 - 11.5 Ma

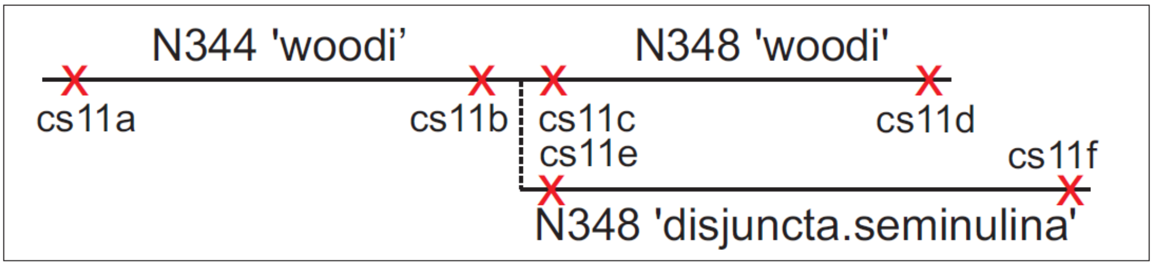


Figure 4.13 The evolutionary relationships between the Hennigian lineages N344 'woodi', N348 'woodi' and N348 'disjuncta.seminulina' (Aze *et al*., 2011). An arrow at the end of a lineage indicates that the lineage is extant. Below are detailed descriptions of the morphospecies within these lineages. cs11a – cs11f are the codes assigned to the populations that were sampled at the approximate points marked on the lineages.

Globoturborotalita woodi JENKINS

See Section 4.3.4

Sphaeroidinella disjuncta (FINLAY)

DESCRIPTION

Type of wall: Non-spinose, cancellate.

Test morphology: Low trochospiral, equatorial periphery trilobate to quadrilobate, chambers spherical to ovate, aperture is an interiomarginal umbilical opening bordered by thickened rim

DISTINGUISHING FEATURES -

STRATIGRAPHIC RANGE OF MORPHOSPECIES - 18.1 - 12.1 Ma.

GEOGRAPHIC DISTRIBUTION - Low latitudes (Kennett & Srinivasan, 1983).

STABLE ISOTOPE PALAEOBIOLOGY - Open-ocean thermocline (Aze *et al*. 2011).

Sphaeroidinella seminulina (SCHWAGER)

DESCRIPTION

Type of wall: Non-spinose, cancellate.

Test morphology: Compact, low trochospiral, subglobular, sutures obscured by secondary cortex. Aperture is an umbilical elongate opening bordered by thickened crenulated rim.

DISTINGUISHING FEATURES - Chamber arrangement and shiny secondary cortex.

STRATIGRAPHIC RANGE OF MORPHOSPECIES - 16.4 - 2.3 Ma.

GEOGRAPHIC DISTRIBUTION - Low latitudes (Kennett & Srinivasan, 1983).

STABLE ISOTOPE PALAEOBIOLOGY - Open-ocean thermocline (Stewart, 2003).

DISCUSSION - *S. seminulina* and *S. disjuncta* were both quite large morphospecies with distinctive chamber arrangements and *S. disjuncta* also has a reflective shiny cortex which aided identification. See Section 4.3.4 for details of *G. woodi*.

4.3. Results

4.3.1 Initial results

The following section summarises the size data collected from the case studies described in Section 4.3.1. The raw data are provided in the Electronic Appendix - Part E, from hereon the size data will refer only to the mean area (µm) of each population sampled.

Table 4.1 the following table contains information about the time periods and morphospecies that were sampled for each randomly selected lineage from the Neogene. Also included is the mean area in µm and the standard deviation of each population.

Lineage code	Morphospecies in lineage	Sample code	Time myr (± 1myr)	Bio-zone	Sample	Mean area (µm)	Standard deviation
N300	*Globigerinella siphonifera*	cs1a	10.3	M13a	GLOW 10 Box base	112784.0	35042.5
N300	*Globigerinella siphonifera*	cs1b	3.8	Pl2	872C 3H 3 60-62	147969.0	79336.9
T304	*Globigerinella siphonifera*	cs1c	3.8	Pl2	872C 3H 1 59-61	146635.7	51198.6
T304	*Globigerinella siphonifera*	cs1d	0.0	Pt1b	GLOW 3 Box Top	156627.0	75437.8
N301	*Globigerinella calida*	cs1e	3.8	Pl2	872C 3H 1 59-61	88179.6	31765.2
N301	*Globigerinella calida*	cs1f	0.3	Pt1b	GLOW 3 Box top	124435.0	65687.0
N337	*Globigerina connecta. Globigerinoides trilobus*	cs2a	22.5	M1b	925A 19R 3 74-76	75334.5	9744.2
N337	*Globigerina connecta. Globigerinoides trilobus*	cs2b	17.0	M4a	872C 13H 4 78-80	72016.3	25602.0
N339	*Globigerinoides trilobus. G. sacculifer*	cs2c	17.0	M4a	872C 2H 6 122-124	147773.9	53161.5
N339	*Globigerinoides trilobus. G. sacculifer*	cs2d	3.3	Pl3	872C 3H 3 59-61	247720.7	116483.8
T338	*Globigerinoides bisphericus. Praeorbulina sicanus. P. curva. P. glomerosa. P. circularis. Orbulina universa*	cs2e	17.0	M4a	871A 1H 1 124-126	75375.9	21995.1
T338	*Globigerinoides bisphericus. Praeorbulina sicanus. P. curva. P. glomerosa. P. circularis. Orbulina universa*	cs2f	0.0	Pt1b	GLOW 3 Box top	77105.9	16423.3
N349	*Globoturborotalita decoraperta. G. tenella. G. rubescens*	cs3a	14.3	M7	872C 9H 2 20-22	74877.2	25270.4
N349	*Globoturborotalita decoraperta. G. tenella. G. rubescens*	cs3b	2.0	Pl6	872C 2H 158-60	24269.0	5601.2
T350	*Globoturborotalita rubescens*	cs3c	2.0	Pl6	871A 1H 1 124-126	24631.9	7171.9
T350	*Globoturborotalita rubescens*	cs3d	0.0	Pt1b	GLOW 3 Box top	21946.3	5438.0
T351	*Globoturborotalita tenella*	cs3e	2.0	Pl6	871A 1H 1 124-126	28486.9	7536.2
T351	*Globoturborotalita tenella*	cs3f	0.0	Pt1b	GLOW 3 Box top	33677.6	8133.4
N354	*Globoturborotalita woodi*	cs4a	12.1	M9b	1137A 4R CC	19606.3	4473.5
N354	*Globoturborotalita woodi*	cs4b	11.5	M11	1137A 3R CC	45778.3	9631.5
T356	*Globoturborotalita woodi. G. apertura*	cs4c	11.5	M11	872C 5H 6 59-61	30052.6	6868.6
T356	*Globoturborotalita woodi. G. apertura*	cs4d	1.3	Pt1a	872C 3H 6 59-51	30124.4	5254.9
T355	*Globoturborotalita nepthenthes*	cs4e	11.5	M11	872C 5H 6 59-61	60455.6	19540.5

Lineage code	Morphospecies in lineage	Sample code	Time myr (± 1myr)	Bio-zone	Sample	Mean area (µm)	Standard deviation
T355	*Globoturborotalita nepthenthes*	cs4f	4.3	Pl1b	872C 3H 6 59-61	66048.2	20129.4
N344	*Globoturborotalita woodi*	cs5c	21.1	M2	1137A 11R CC	46704.8	11783.0
N344	*Globoturborotalita woodi*	cs5d	17.3	Pt1b	GLOW 3 Box top	47285.4	9825.6
N64	*Truncorotalia truncatulinoides. T. excelsa. T. pachytheca*	cs6a	1.4	Pt1a	871A 2H 3	96509.4	24905.5
N64	*Truncorotalia truncatulinoides. T. excelsa. T. pachytheca*	cs6b	0.8	Pt1a	871A 2H 6	167738.6	39168.8
T66	*Truncorotalia truncatulinoides. T. excelsa. T. pachytheca*	cs6c	0.8	Pt1a	871A 1H 1	113709.1	29685.4
T66	*Truncorotalia truncatulinoides. T. excelsa. T. pachytheca*	cs6d	0.0	Pt1b	GLOW 3 Box top	222321.7	54502.4
N157	*Neogloboquadrina continuosa. N. acostaensis*	cs7a	10.8	M12	GLOW 10 Box base	98998.6	27700.0
N157	*Neogloboquadrina continuosa. N. acostaensis*	cs7b	8.0	M13b	872C 5H 3 59-61	65551.2	15396.4
N160	*Neogloboquadrina continuosa. N. acostaensis*	cs7c	8.0	M13b	872C 5H 2 59-60	65955.2	13521.2
N160	*Neogloboquadrina continuosa. N. acostaensis*	cs7d	5.7	M14	872C 4H 3 59-61	64407.0	13873.6
T158	*Neogloboqudrina humerosa. N. dutertrei*	cs7e	8.0	M13b	872C 5H 2 59-61	66889.1	13785.6
T158	*Neogloboqudrina humerosa. N. dutertrei*	cs7f	0.0	Pt1b	GLOW 3 Box top	140172.5	46327.6
N35	*Menardella limbata*	cs8a	13.0	M13a	872C 5H 1 59-61	439162.3	169247.9
N35	*Menardella limbata*	cs8b	6.5	M13a	872C 4H 2 115-117	437491.9	101124.0
N37	*Menardella limbata*	cs8c	6.5	M13b	872C 4H 1 59-61	457033.4	95568.3
N37	*Menardella limbata*	cs8d	5.7	M14	872C 3H CC	352492.3	90444.3
T36	*Menardella multicamerata*	cs8e	6.5	M13b	872C 4H 1 59-61	577652.1	136042.6
T36	*Menardella multicamerata*	cs8f	2.2	Pl6	872C 3H 1 59-61	531690.7	138740.9
N332	*Globigerinoides subquadratus*	cs9c	21.0	M2	872C 11H CC	144552.3	31474.3
N332	*Globigerinoides subquadratus*	cs9d	17.5	M3	872C 11H 3 78-80	82124.0	33792.4
N327	*Globigerinoides altiapertura. G. obliquus*	cs9e	21.0	M2	872C 11H CC	88696.0	30289.7
N327	*Globigerinoides altiapertura. G. obliquus*	cs9f	7.5	M13b	872C 5H 5 59-61	80698.6	19028.9
N334	*Globigerinoides subquadratus. G. diminutus*	cs10a	17.5	M3	872 11H 3 78-80	82124.0	33792.4
N334	*Globigerinoides subquadratus. G. diminutus*	cs10b	15.1	M5b/ M6	871A 8H 1	61704.3	13834.8
T360	*Globigerinoides subquadratus*	cs10c	15.1	M5b/ M6	871A 7H 5 124-126	52238.4	12657.7
T360	*Globigerinoides subquadratus*	cs10d	10.8	M13a	872C 5H 1 59-60	58940.0	14799.4
T335	*Globigerinoides ruber. G. seiglei*	cs10e	15.1	M5b/ M6	871A 7H 5 124-126	46810.7	14574.3
T335	*Globigerinoides ruber. G. seiglei*	cs10f	0.0	Pt1b	GLOW 3 Box top	80582.6	31058.4
N344	*Globoturborotalita woodi*	cs11a	21.1	M2	1137A 11R CC	46704.8	11783.0
N344	*Globoturborotalita woodi*	cs11b	17.3	M3/M 4a	1137A 9R CC	53088.6	10379.2
N348	*Globoturborotalita woodi*	cs11c	17.3	M3/M 4a	1137A 8R CC	47285.4	9825.6
N348	*Globoturborotalita woodi*	cs11d	14.3	M7	1137A 5R CC	80932.0	23960.5

Lineage code	Morphospecies in lineage	Sample code	Time myr (± 1myr)	Bio-zone	Sample	Mean area (μm)	Standard deviation
N345	*Sphaeroidinellopsis disjuncta. G. seminulina*	cs11e	17.3	M3/M 4a	872C 11H 4 20-23	117562.3	24828.8
N345	*Sphaeroidinellopsis disjuncta. G. seminulina*	cs11f	11.5	M11	872 C 6H CC	96770.6	22579.4

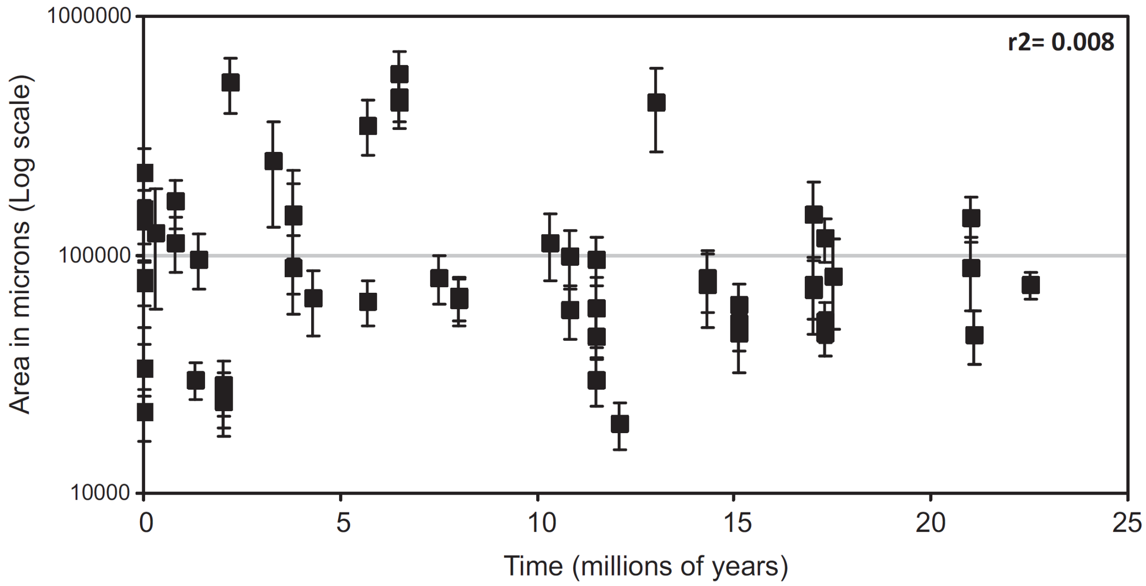


Figure 4.14 Mean sizes (μm^2) of all randomly sampled Neogene lineages with standard deviation, plotted on a log scale. r^2 = 0.008 (see Appendix 2 for analysis) illustrating no correlation between size and time. The apparent increase in variance is likely due to the increased abundance of samples towards the recent as four samples represent the descendants in the case studies, whereas only two samples represent the ancestor.

4.4.2 Results of individual case studies

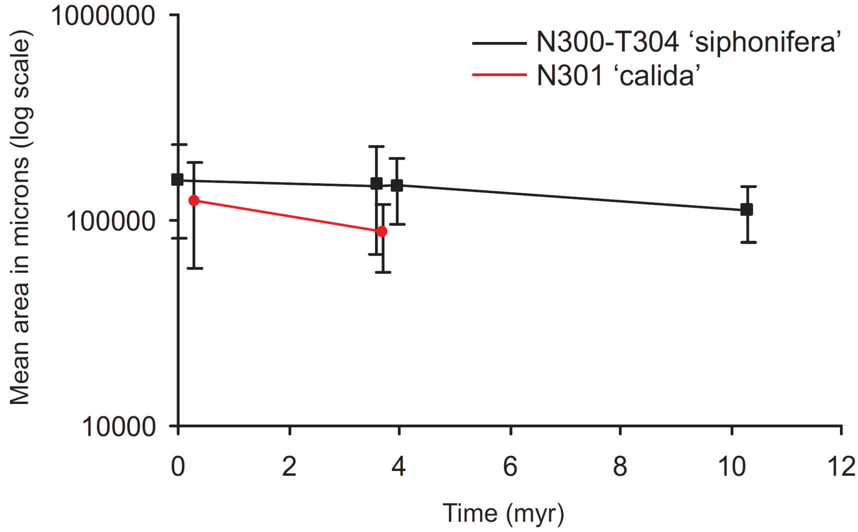
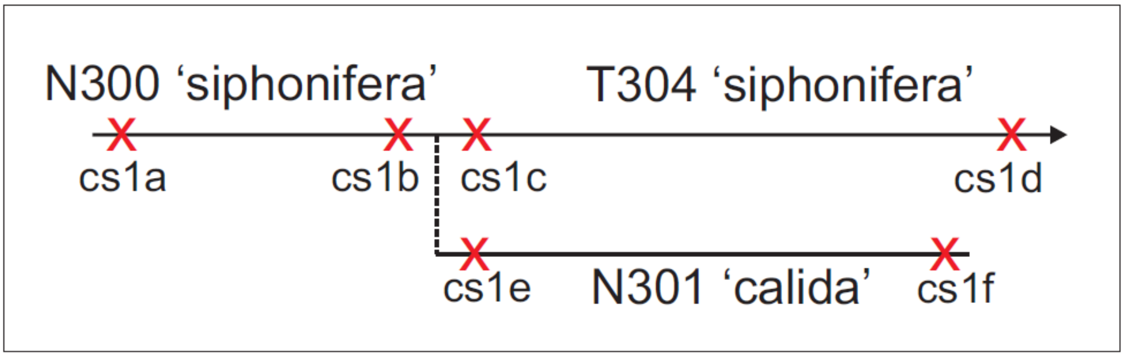


Figure 4.15 Case study 1: N300 'siphonifera'and T304 'siphonifera', N301 'calida'.

The 'siphonifera' lineages both show an increase in mean area over time. The ancestral form has a more notable size increase and the populations either size of cladogenesis are virtually the same. The descendant linage 'calida' is founded at a smaller size than its contemporaneous ancestral population and remains smaller than it contemporaneous ancestor in the end of lineage population. N300-T304 The errors bars in this and all the following graphs represent the standard deviation of the total range of size about the mean.



A-B comparision	Mean size of A	Mean size of B	T statistic	p: critical value	Decision
cs1a - cs1b	112784	147969	-4.0568	8.34E-05	Reject null. Descendant population is bigger
cs1c - cs1d	146635.7	156627	-1.0959	0.2746	Null. Populations are the same size
cs1e - cs1f	88179.6	124435	-3.9397	0.0001848	Reject null. Descendant population is bigger
cs1a - cs1d	112784	156627	-5.2709	5.03E-07	Reject null. Descendant population is bigger
cs1a - cs1c	112784	146635.7	-5.4562	1.64E-07	Reject null. Descendant population is bigger
cs1a - cs1e	112784	88179.6	5.1783	5.56E-07	Null. Descendant population is smaller
cs1a - cs1f	112784	124435	-1.2515	0.2146	Null. Populations are the same size
cs1b - cs1c	147969	146635.7	0.1412	0.8879	Null. Populations are the same size
cs1b - cs1e	147969	88179.6	6.9864	1.30E-10	Null. Populations are the same size
cs1b - cs1d	147969	156627	-0.7909	0.43	Null. Populations are the same size
cs1b - cs1f	147969	124435	2.0082	0.04658	Null. Descendant population is smaller
cs1c - cs1e	146635.7	88179.6	9.6745	2.20E-16	Null. Descendant population is smaller
cs1d - cs1f	156627	124435	2.8094	0.005714	Null. Descendant population is smaller

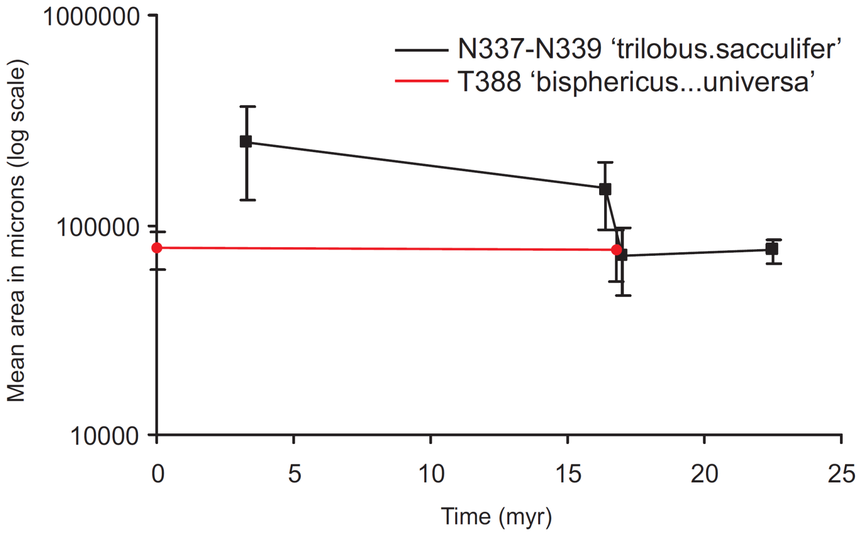
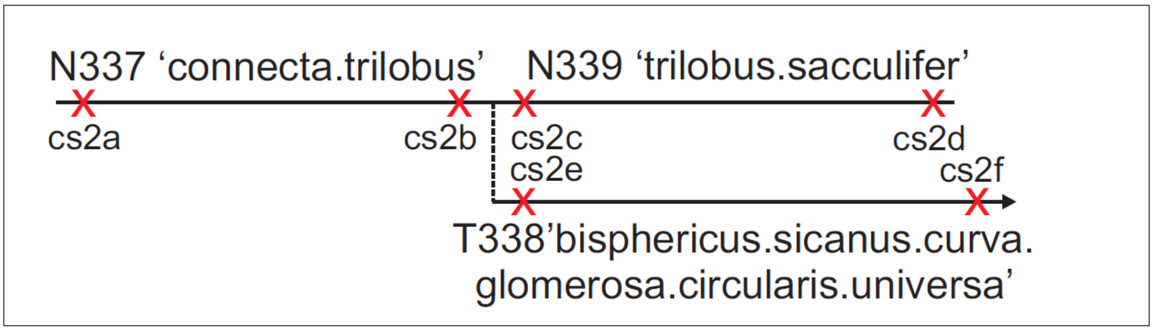


Figure 4.16 Case study 2: N337 'connecta.trilobus' and N339 'trilobus.sacculifer', T338 'bisphericus.sicanus.curva.glomerosa.circularis.universa'.

The ancestral lineage 'connecta.trilobus' exhibits no significant change in mean size, but then demonstrates a sharp increase in size after cladogenesis with the ensuing descendant lineage increasing in mean size over time. The descendant lineage 'bisphericus.sicanus.curva.glomerosa.circularis.universa' shows no change in mean size over time and the older descendant population is the same size as the cotemporaneous ancestral population.



A-B comparision	Mean size of A	Mean size of B	T statistic	p: critical value	Decision
cs2a - cs2b	75334.49	72016.3	1.0263	0.3061	Null. Descendant population is smaller
cs2c - cs2d	147773.9	247720.7	-7.8058	1.31E-12	Reject null. Descendant population is bigger
cs2e - cf2f	75375.87	77105.87	-0.6302	0.5293	Null. Populations are the same size
cs2a - cs2d	75334.49	247720.69	-14.591	2.20E-16	Reject null. Descendant population is bigger
cs2a - cs2c	75334.49	147773.86	-12.7738	2.20E-16	Reject null. Descendant population is bigger
cs2a - cs2e	75334.49	75375.87	-0.014	0.9888	Null. Populations are the same size
cs2a - cs2d	75334.49	247720.69	-14.591	2.20E-16	Reject null. Descendant population is bigger
cs2a - cs2f	75334.49	77105.87	-0.6897	0.4912	Null. Populations are the same size
cs2b - cs2c	72016.3	147773.9	-12.8392	2.20E-16	Reject null. Descendant population is bigger
cs2b - cs2e	72016.3	75375.87	-0.9953	0.3208	Null. Populations are the same size
cs2b - cs2d	72016.3	247720.7	-14.7324	2.20E-16	Reject null. Descendant population is bigger
cs2b - cs2f	72016.3	77105.87	-1.6733	0.09613	Null. Populations are the same size
cs2c - cs2e	147773.86	75375.87	12.584	2.20E-16	Null. Descendant population is smaller
cs2d - cs2f	247720.69	77105.87	14.5036	2.20E-16	Null. Descendant population is smaller

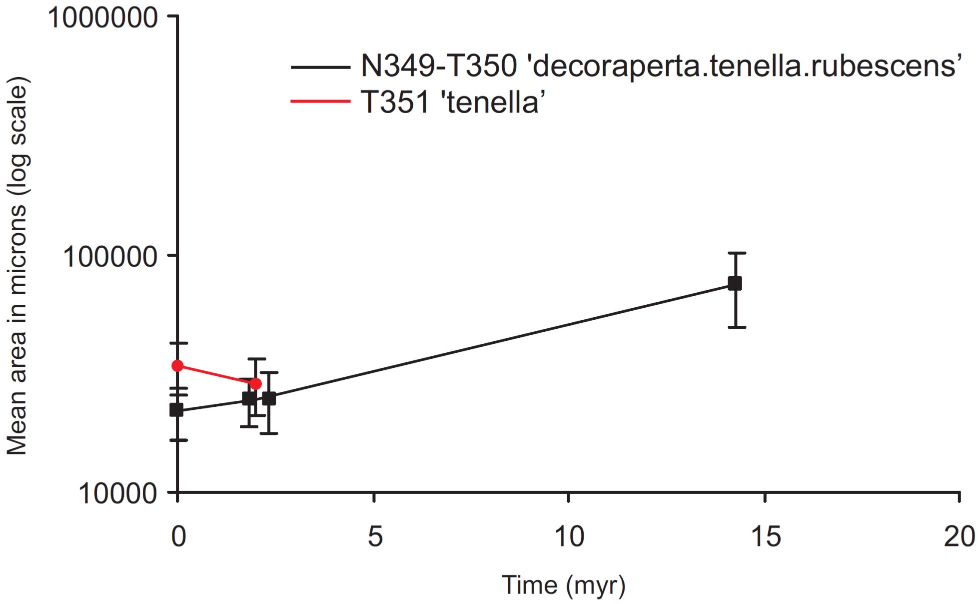
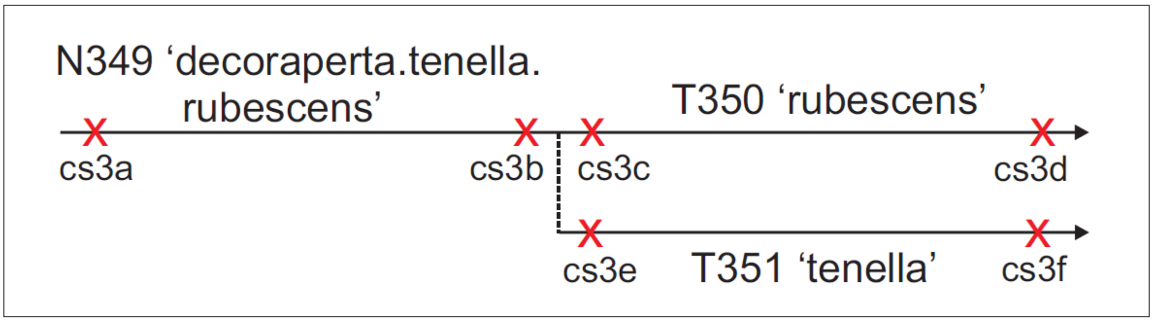


Figure 4.17 Case study 3: N349 'decoraperta.tenella.rubescens', T350 'rubescens' and T351 'tenella'. The ancestral lineage and continuing evolutionary descendant ('decoraperta.tenella.rubescens', and 'rubescens') demonstrate a decrease in mean area over time. The new descendant species shows the opposite trend and shows an increase in mean area over time, but is founded at smaller size then the earlier ancestor population.



A-B comparision	Mean size of A	Mean size of B	T statistic	p: critical value	Decision
cs3a - cs3b	74877.19	24268.96	19.5522	2.20E-16	Null. Descendant population is smaller
cs3c - cs3d	24631.86	21946.31	2.9838	0.003232	Null. Descendant population is smaller
cs3e - cs3f	28486.87	33677.64	-4.2387	4.00E-05	Reject null. Descendant population is bigger
cs3a - cs3d	74877.19	21946.31	20.4771	2.20E-16	Null. Descendant population is smaller
cs3a - cs3c	74877.19	24631.86	19.1277	2.20E-16	Null. Descendant population is smaller
cs3a - cs3e	74877.19	28486.87	17.592	2.20E-16	Null. Descendant population is smaller
cs3a - cs3d	74877.19	21946.31	20.4771	2.20E-16	Null. Descendant population is smaller
cs3a - cs3f	74877.19	33677.64	15.2303	2.20E-16	Null. Descendant population is smaller
cs3b - cs3c	24268.96	24631.86	-0.3988	0.6905	Null. Populations are the same size
cs3b - cs3e	24268.96	28486.87	-4.492	1.25E-05	Reject null. Descendant population is bigger
cs3b - cs3d	24268.96	21946.31	2.9752	0.003293	Null. Descendant population is smaller
cs3b - cs3f	24268.96	33677.64	-8.4307	1.09E-13	Reject null. Descendant population is bigger
cs3c - cs3e	24631.86	28486.87	-3.7055	0.0002738	Reject null. Descendant population is bigger
cs3d - cs3f	21946.31	33677.64	-10.5888	2.20E-16	Reject null. Descendant population is bigger

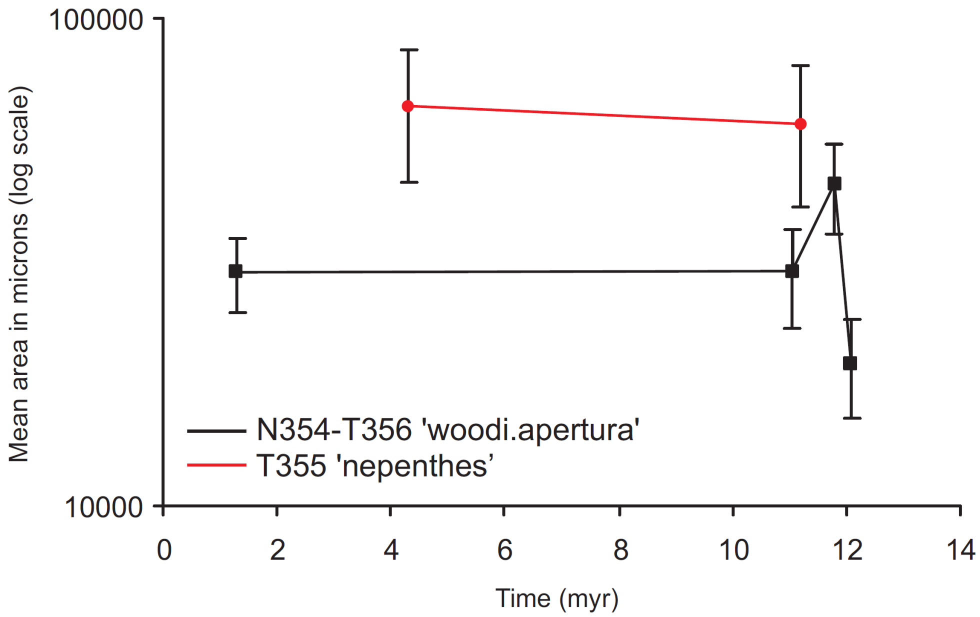
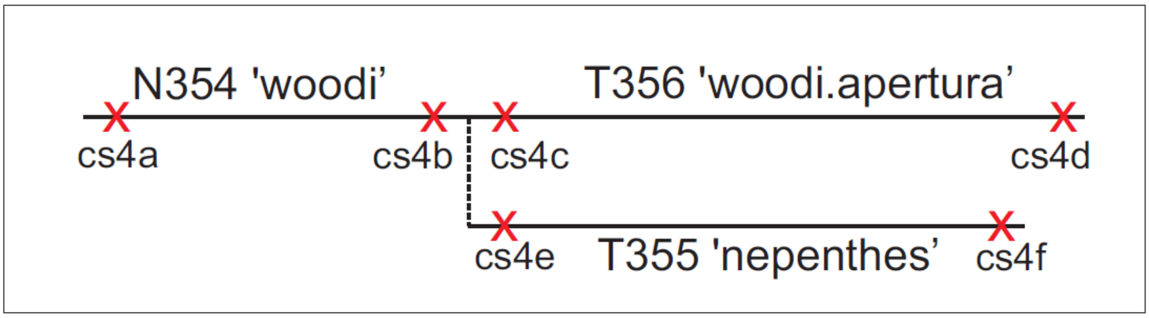


Figure 4.18 Case study 4: N354 'woodi' and T356 'woodi.apertura', T355 'nepenthes'.

The ancestral form shows extreme variation in size along its evolutionary lineage and don't show descendant populations consistently bigger than ancestor populations, as Hennigian lineages, however, both conform to Cope's rule. 'nepenthes' does show an increase in mean area over time.



A-B comparision	Mean size of A	Mean size of B	T statistic	p: critical value	Decision
cs4a - cs4b	19606.26	45778.32	-24.6448	2.20E-16	Reject null. Descendant population is bigger
cs4c - cs4d	30052.61	30124.42	-0.083	0.9339	Null. Populations are the same size
cs4e - cs4f	60455.61	66048.16	-1.9935	0.04758	Reject null. Descendant population is bigger
cs4a - cs4d	19606.26	30124.42	-15.241	2.20E-16	Reject null. Descendant population is bigger
cs4a - cs4c	19606.26	30052.61	-12.7442	2.20E-16	Reject null. Descendant population is bigger
cs4a - cs4e	19606.26	60455.61	-20.3778	2.20E-16	Reject null. Descendant population is bigger
cs4a - cs4d	19606.26	30124.42	-15.241	2.20E-16	Reject null. Descendant population is bigger
cs4a - cs4f	19606.26	66048.16	-22.5222	2.20E-16	Reject null. Descendant population is bigger
cs4b - cs4c	45778.32	30052.61	13.2933	2.20E-16	Null. Descendant population is smaller
cs4b - cs4e	45778.32	60455.61	-6.7373	3.57E-10	Reject null. Descendant population is bigger
cs4b - cs4d	45778.32	30124.42	14.2674	2.20E-16	Null. Descendant population is smaller
cs4b - cs4f	45778.32	66048.16	-9.0835	8.14E-16	Reject null. Descendant population is bigger
cs4c - cs4e	30052.61	60455.61	-14.6786	2.20E-16	Reject null. Descendant population is bigger
cs4d - cs4f	30124.42	66048.16	-17.2677	2.20E-16	Reject null. Descendant population is bigger

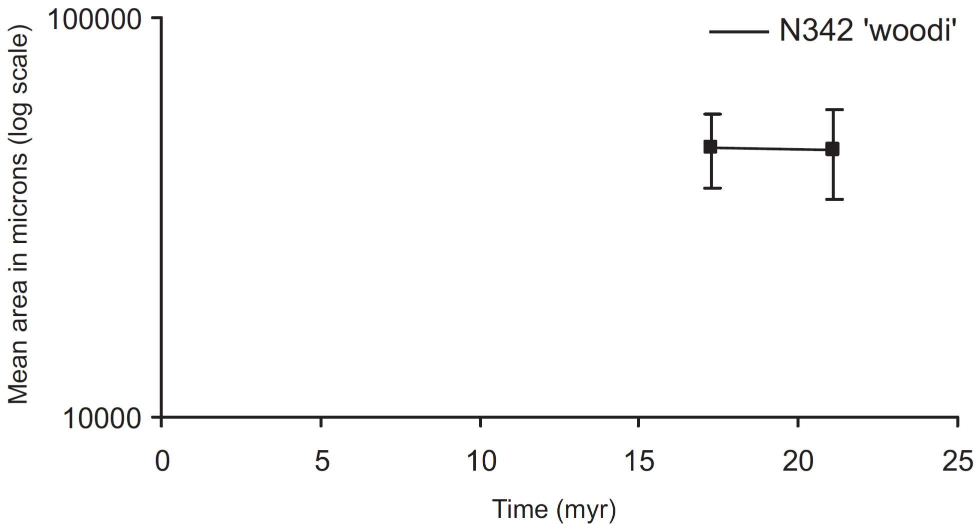
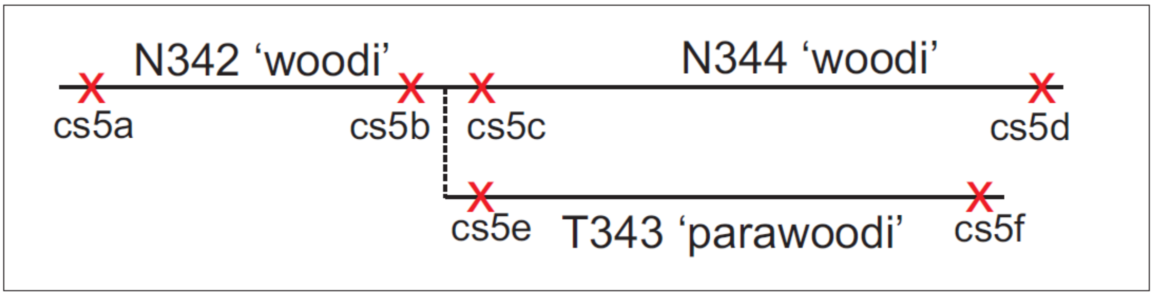


Figure 4.19 Case study 5: N342 'woodi'.

Only one lineage was found for case study 5, and the ancestral and descendant populations of this lineage statistically have the same mean size.



A-B comparision	Mean size of A	Mean size of B	T statistic	p: critical value	Decision
cs5c - cs5d	46704.82	47285.42	-0.3784	0.7055	Null. Populations are the same size

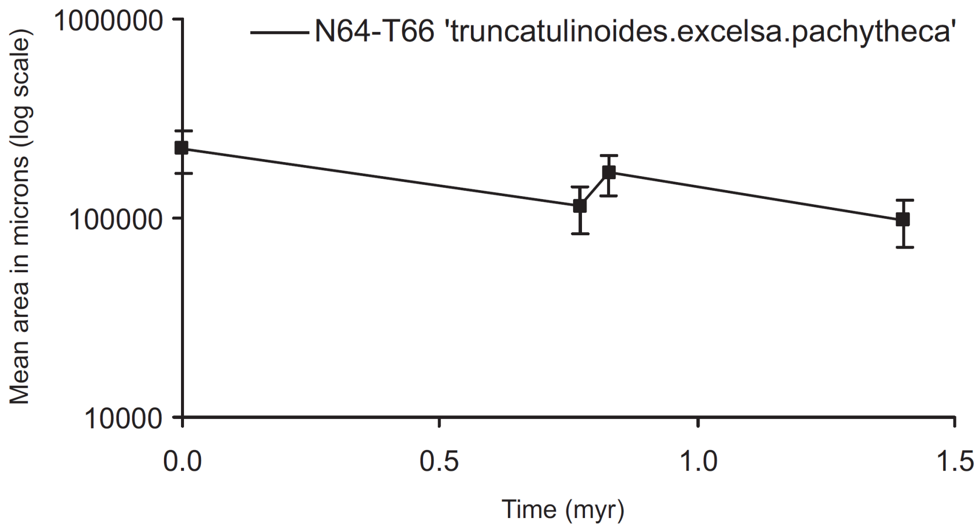
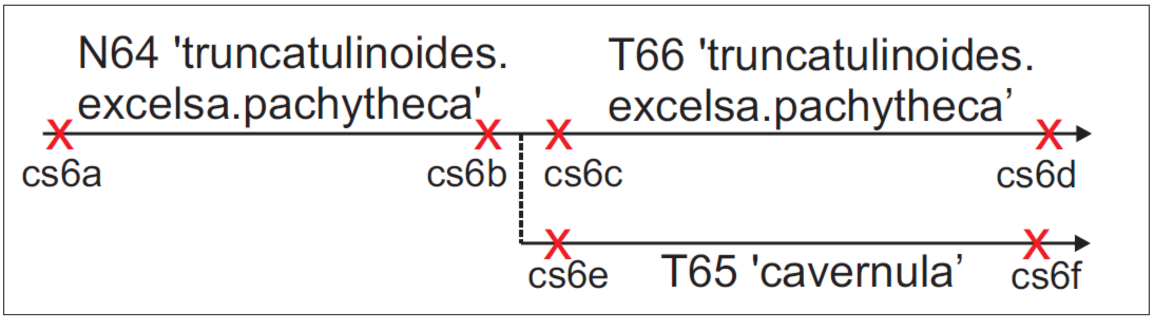


Figure 4.20 Case study 6: N64 'truncatulinoides.excelsa.pachytheca' and T66'truncatulinoides.excelsa.pachytheca'.

The lineage 'cavernula' was not found in the sediment analysed. Both 'truncatulinoides.excelsa.pachytheca' lineages show increases in mean size as Hennigian lineages, but not consistently as an individual evolutionary lineage.



A-B comparision	Mean size of A	Mean size of B	T statistic	p: critical value	Decision
cs6a - cs6b	96509.43	167738.65	-15.3457	2.20E-16	Reject null. Descendant population is bigger
cs6c - cs6d	113709.1	222321.7	-17.5006	2.20E-16	Reject null. Descendant population is bigger
cs6a - cs6d	96509.43	222321.68	-20.9956	2.20E-16	Reject null. Descendant population is bigger
cs6a - cs6c	96509.43	113709.13	-4.4387	1.52E-05	Reject null. Descendant population is bigger
cs6b - cs6c	167738.6	113709.1	10.9935	2.20E-16	Null. Descendant population is smaller

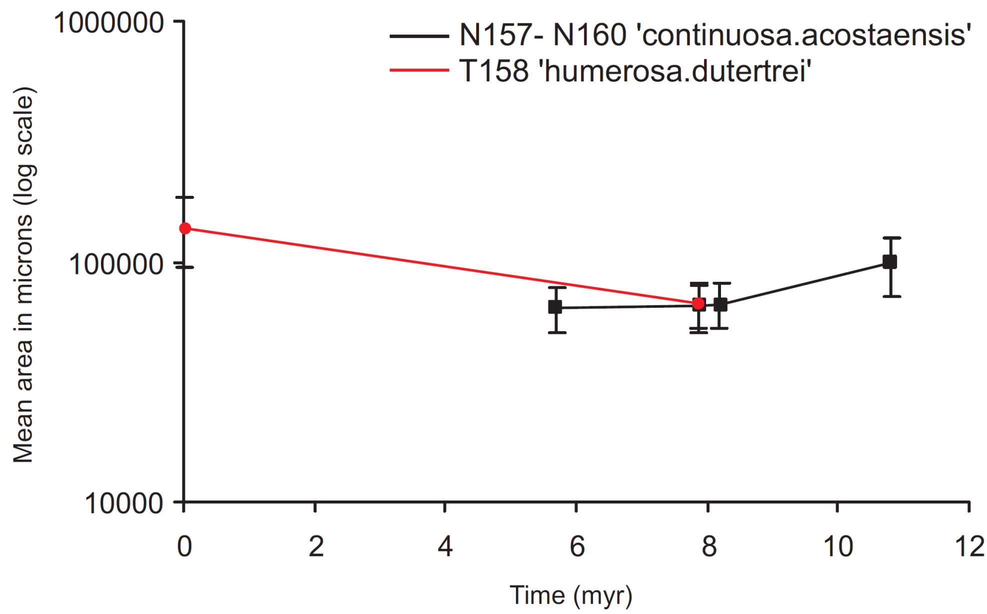
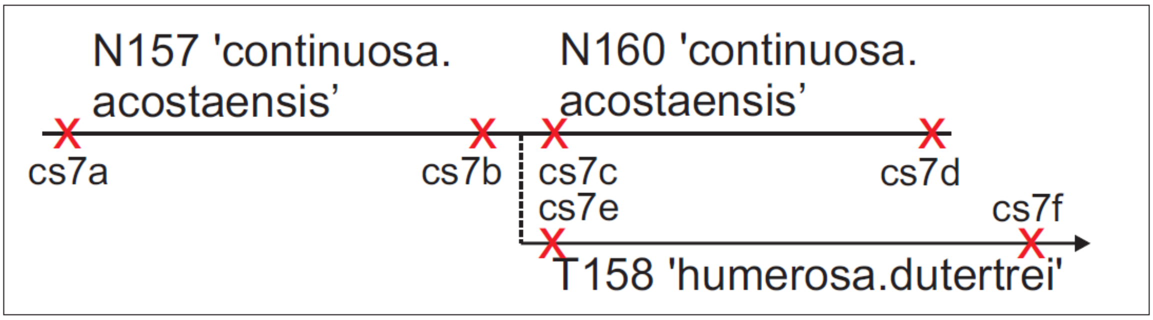


Figure 4.21 Case study 7: N157 'continuosa.acostaensis' and N160 'continuosa.acostaensis', T158 'humerosa.dutertrei'.

The ancestral and descendant lineages 'continuosa.acostaensis' both show a decrease in mean size over time. The descendant 'humerosa.dutertrei' shows an increase in mean size and although the same size as the contemporaneous ancestral population it is founded at smaller size than the original ancestral population.



A-B comparision	Mean size of A	Mean size of B	T statistic	p: critical value	Decision
cs7a - cs7b	98998.58	65551.21	10.5541	2.20E-16	Null. Descendant population is smaller
cs7c - cs7d	65955.2	64406.98	0.6862	0.4939	Null. Populations are the same size
cs7e - cs7f	66889.14	140172.54	-15.1615	2.20E-16	Reject null. Descendant population is bigger
cs7a - cs7d	98998.58	64406.98	10.4606	2.20E-16	Null. Descendant population is smaller
cs7b - cs7c	65551.21	65955.2	-0.1972	0.8439	Null. Populations are the same size
cs7b - cs7e	65551.21	66889.14	-0.6474	0.5181	Null. Populations are the same size
cs7c - cs7e	65955.2	66889.14	-0.4837	0.6292	Null. Populations are the same size
cs7d - cs7f	64406.98	140172.54	-15.2372	2.20E-16	Reject null. Descendant population is bigger

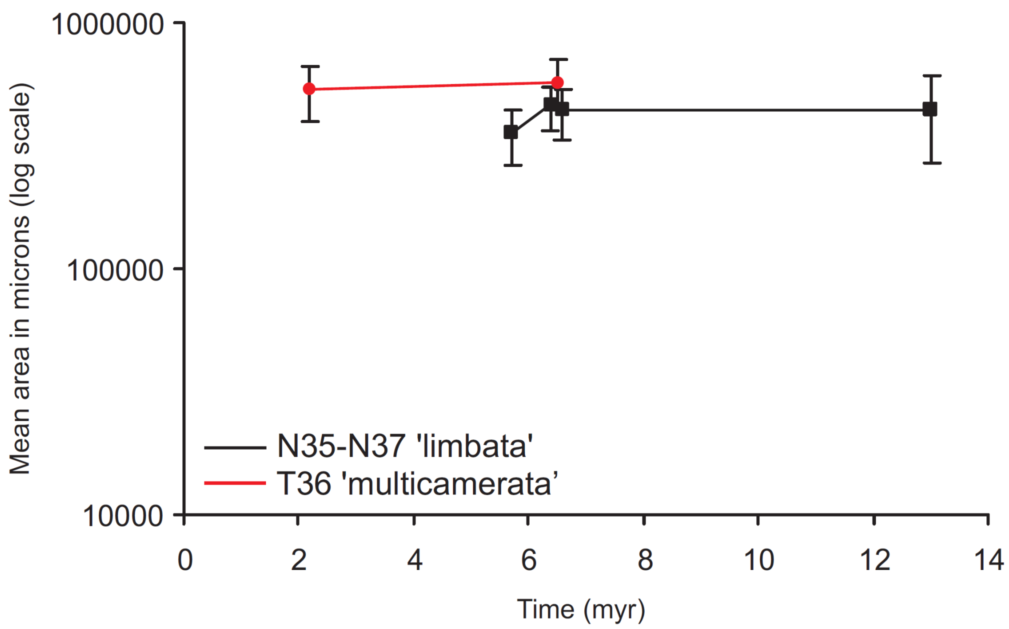
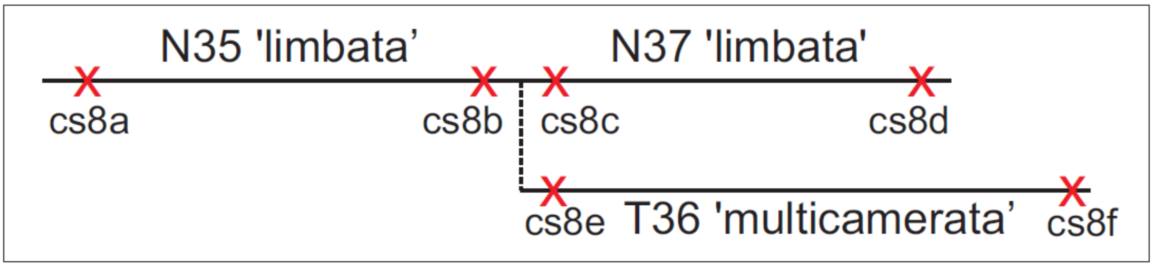


Figure 4.22 Case study 8: N35 'limbata' and N37 'limbata' and T36 'multicamerata'.

The ancestral lineage of 'limbata' show no change in mean area over time. The descendant 'limbata' and 'multicamerata' lineages show no increase in mean area, with a decrease and no change in mean area respectively.



A-B comparision	Mean size of A	Mean size of B	T statistic	p: critical value	Decision
cs8a - cs8b	439162.3	437491.9	0.0847	0.9326	Null. Populations are the same size
cs8c - cs8d	457033.4	352492.3	5.3384	2.91E-06	Null. Descendant population is smaller
cs8e - cs8f	577652.1	531690.7	1.0006	0.3389	Null. Populations are the same size
cs8a - cs8d	439162.3	352492.3	3.6031	0.0005319	Null. Descendant population is smaller
cs8a - cs8c	439162.3	457033.4	-0.9195	0.3593	Null. Populations are the same size
cs8a - cs8e	439162.3	577652.1	-6.3777	1.34E-09	Reject null. Descendant population is bigger
cs8a - cs8d	439162.3	352492.3	3.6031	0.0005319	Null. Descendant population is smaller
cs8a - cs8f	439162.3	531690.7	-1.9676	0.07295	Null. Populations are the same size
cs8b - cs8c	437491.9	457033.4	-1.4045	0.1618	Null. Populations are the same size
cs8b - cs8e	437491.9	577652.1	-8.2685	2.72E-14	Reject null. Descendant population is bigger
cs8b - cs8d	437491.9	352492.3	4.28	8.97E-05	Null. Descendant population is smaller
cs8b - cs8f	437491.9	531690.7	-2.0922	0.06295	Reject null. Descendant population is bigger
cs8c - cs8e	457033.4	577652.1	-7.255	1.20E-11	Reject null. Descendant population is bigger
cs8d - cs8f	352492.3	531690.7	-3.8058	0.002559	Reject null. Descendant population is bigger

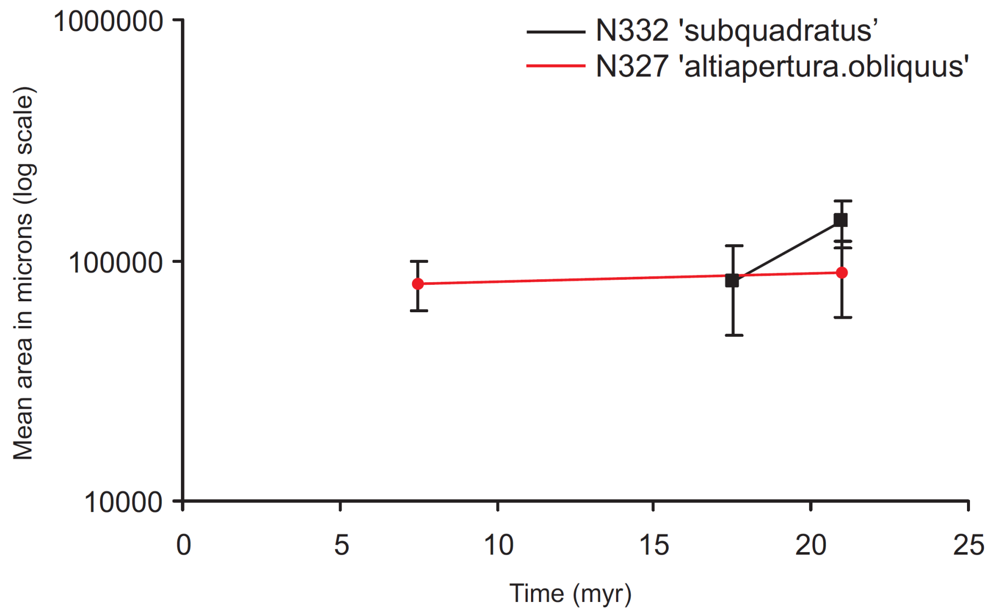
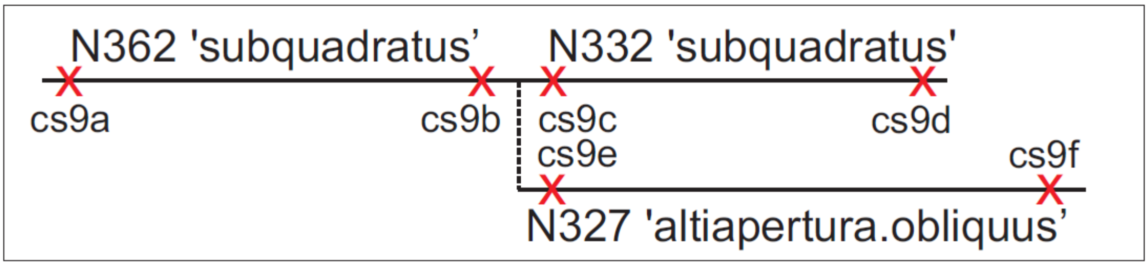


Figure 4.23 Case study 9: N332 'subquadratus', N327 'altiapertura.obliquus'.

No ancestral lineage was found in the sediment analysed for this case study. The descendant lineages both show a decrease in mean area and the derived lineage 'altiapertura.obliquus' is founded at smaller size than its contemporaneous ancestor.



A-B comparision	Mean size of A	Mean size of B	T statistic	p: critical value	Decision
cs9c - cs9d	144552.32	82124.04	13.5186	2.20E-16	Null. Descendant population is smaller
cs9e - cs9f	88696.01	80698.56	2.2357	0.0267	Null. Descendant population is smaller
cs9c - cs9e	144552.32	88696.01	12.7871	2.20E-16	Null. Descendant population is smaller
cs9d - cs9f	82124.04	80698.56	0.3676	0.7137	Null. Populations are the same size

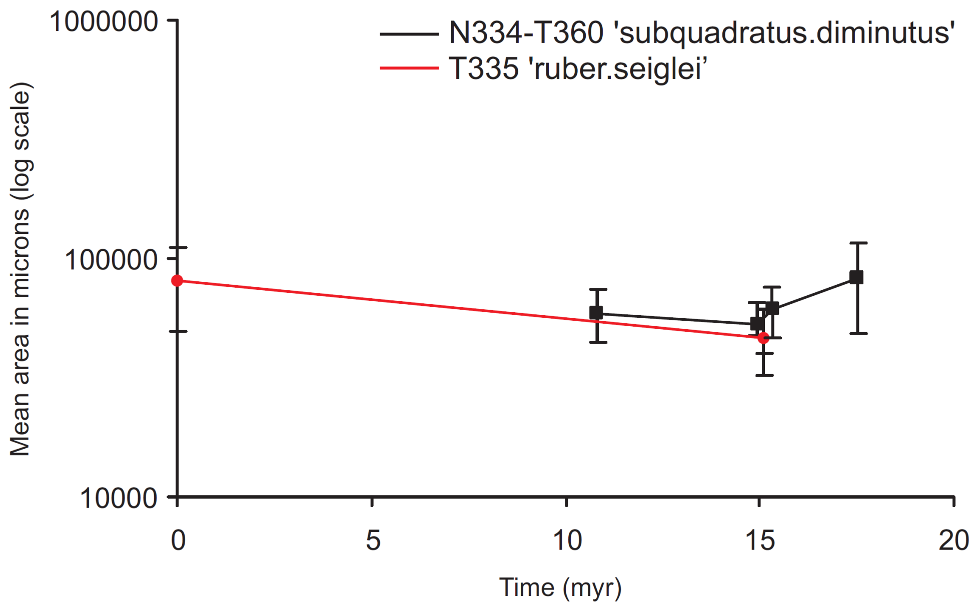
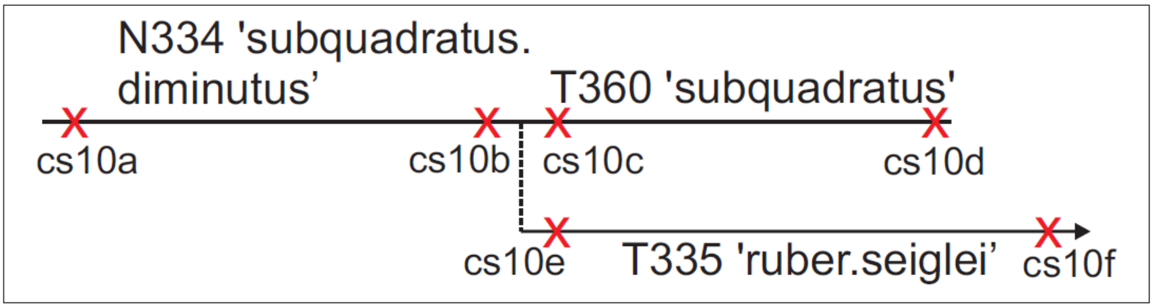


Figure 4.24 Case study 10: N334 'subquadratus.diminutus' and T360 'subquadratus', T335 'ruber.seiglei'. The ancestral lineage 'subquadratus.diminutus' shows a decrease in mean area over time, with a further decrease after cladogenesis. Both descendant lineages show an increase in mean size over time.



A-B comparision	Mean size of A	Mean size of B	T statistic	p: critical value	Decision
cs10a - cs10b	82124.04	61704.33	5.5922	1.25E-07	Null. Descendant population is smaller
cs10c - cs10d	52238.36	58939.96	-3.4413	0.0007094	Reject null. Descendant population is bigger
cs10e - cs10f	46810.74	80582.56	-9.8437	2.20E-16	Reject null. Descendant population is bigger
cs10a - cs10d	82124.04	58939.96	6.2845	4.18E-09	Null. Descendant population is smaller
cs10a - cs10c	82124.04	52238.36	8.282	1.50E-13	Null. Descendant population is smaller
cs10a - cs10e	82124.04	46810.74	9.5957	2.20E-16	Null. Descendant population is smaller
cs10a - cs10d	82124.04	58939.96	6.2845	4.18E-09	Null. Descendant population is smaller
cs10a - cs10f	82124.04	80582.56	0.3359	0.7373	Null. Populations are the same size
cs10b - cs10c	61704.33	52238.36	5.0481	1.01E-06	Null. Descendant population is smaller
cs10b - cs10e	61704.33	46810.74	7.4116	3.57E-12	Null. Descendant population is smaller
cs10b - cs10d	61704.33	58939.96	1.3645	0.174	Null. Populations are the same size
cs10b - cs10f	61704.33	80582.56	-5.5524	1.42E-07	Reject null. Descendant population is bigger
cs10c - cs10e	52238.36	46810.74	2.8117	0.005434	Null. Descendant population is smaller
cs10d - cs10f	58939.96	80582.56	-6.2907	3.69E-09	Reject null. Descendant population is bigger

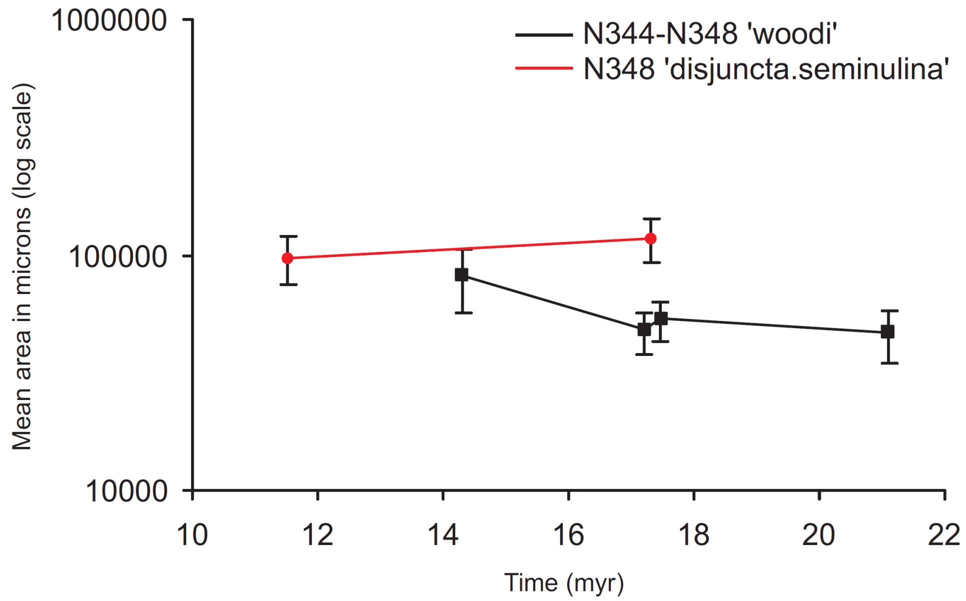
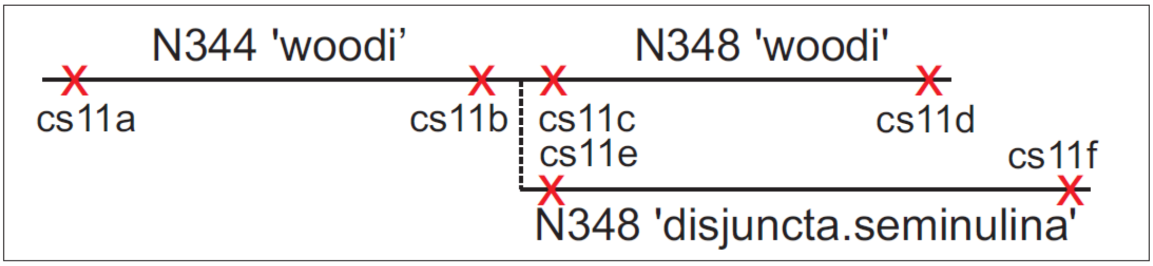


Figure 4.25 Case study 11: N344 'woodi' and N348 'woodi', N348 'disjuncta.seminulina'.

The ancestral lineage 'woodi' shows an increase in mean area over time, with a decrease in size after cladogenesis. The descendant 'woodi' lineage then exhibits and increase in mean area while the descendant 'disjuncta.seminulina', although founded at larger size than it contemporaneous ancestor, shows a decrease in mean area.



A-B comparision	Mean size of A	Mean size of B	T statistic	p: critical value	Decision
cs11a - cs11b	46704.82	53088.56	-4.0654	6.95E-05	Reject null. Descendant population is bigger
cs11c - cs11d	47285.42	80931.98	-12.9925	2.20E-16	Reject null. Descendant population is bigger
cs11e - cs11f	117092.47	96770.61	6.0553	7.01E-09	Null. Descendant population is smaller
cs11a - cs11d	46704.82	80931.98	-12.8187	2.20E-16	Reject null. Descendant population is bigger
cs11a - cs11c	46704.82	47285.42	-0.3784	0.7055	Null. Populations are the same size
cs11a - cs11e	46704.82	117092.47	-25.6115	2.20E-16	Reject null. Descendant population is bigger
cs11a - cs11d	46704.82	80931.98	-12.8187	2.20E-16	Reject null. Descendant population is bigger
cs11a - cs11f	46704.82	96770.61	-19.6576	2.20E-16	Reject null. Descendant population is bigger
cs11b - cs11c	53088.56	47285.42	4.0603	7.06E-05	Null. Descendant population is smaller
cs11b - cs11e	53088.56	117092.47	-23.7837	2.20E-16	Reject null. Descendant population is bigger
cs11b - cs11d	53088.56	80931.98	-10.6631	2.20E-16	Reject null. Descendant population is bigger
cs11b - cs11f	53088.56	96770.61	-17.5778	2.20E-16	Reject null. Descendant population is bigger
cs11c - cs11e	47285.42	117092.47	-26.1427	2.20E-16	Reject null. Descendant population is bigger
cs11d - cs11f	80931.98	96770.61	-4.8108	2.98E-06	Reject null. Descendant population is bigger

4.3.3 Comparative results

The following section details the results of t-test comparisons of populations from the randomly selected Neogene lineages. The comparisons of mean area have been sub-divided into five phylogenetic relationships which are detailed below (all raw t-test data and analysis can be found in Appendix 2, Section 2.1).

Hennigian Lineages

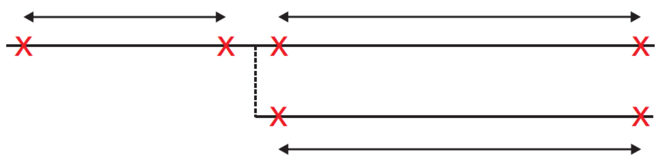


Figure 4.26 A schematic illustrating the pairs of population means (red crosses) that were compared (denoted by the arrows) between ancestors and descendants of individual Hennigian lineages.

Table 4.2 Comparison of Hennigian ancestor and descendant mean t-tests across the whole data set categorised by the result (whether they showed an increase in mean area, a decrease in mean area or had mean areas that were statistically indistinguishable).

Hennigian lineages sample codes	Mean area increases	Mean area decreases	Mean areas the same
cs1a,cs1b	x		
cs1c,cs1d			x
cs1e,cs1f	x		
cs2a,cs2b		x	
cs2c,cs2d	x		
cs2e,cf2f			x
cs3a,cs3b		x	
cs3c,cs3d	x		
cs3e,cs3f		x	
cs4a,cs4b	x		
cs4c,cs4d			x
cs4e,cs4f	x		
cs5e,cs5f			x
cs6a,cs6b	x		
cs6e,cs6f	x		
cs7a,cs7b		x	
cs7c,cs7d			x
cs7e,cs7f	x		
cs8a,cs8b			x
cs8c,cs8d		x	
cs8e,cs8f			x
cs9c,cs9d		x	
cs9e,cs9f		x	
cs10a,cs10b		x	
cs10c,cs10d	x		

cs10e,cs10f	x		
cs11a,cs11b	x		
cs11c,cs11d	x		
cs11e,cs11f	x		

Table 4.3 Proportion of the Hennigian lineages that exhibited size increase, or not. Categories denoted with * are the component parts of the proportion that didn not exhibit size increase. This proportion was composed of Hennigian descendants with smaller mean areas and Hennigian ancestor-descendant means areas that were not statistically different.

Total number of lineages	**29**	**100%**
Size increase	14	48%
No size increase	15	52%
*Size decrease	8	28%
*Same size	7	24%

Evolutionary Lineages

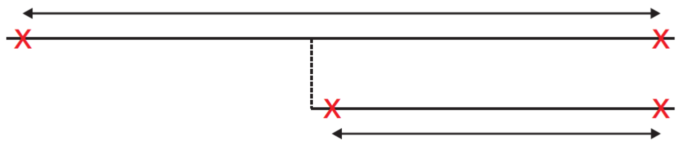


Figure 4.27 A schematic illustrating the pairs of population means (red crosses) that were compared (denoted by the arrows) between ancestors and descendants of individual evolutionary lineages.

Table 4.4 Comparison evolutionary lineage ancestor and descendant means across the whole data set categorised by the result (whether they showed an increase in mean area, a decrease in mean area or had mean areas that were statistically indistinguishable).

Evolutionary lineage sample codes	**Mean area increases**	**Mean area decreases**	**Mean areas the same**
cs1a,cs1d	x		
cs1e,cs1f	x		
cs2a,cs2d	x		
cs2e,cf2f			x
cs3a,cs3d		x	
cs3e,cs3f		x	
cs4a,cs4d	x		
cs4e,cs4f	x		
cs5e,cs5f			x
cs6a,cs6b*	x		
cs6e,cs6f	x		
cs7a,cs7d		x	
cs7e,cs7f	x		

cs8a,cs8d		x	
cs8e,cs8f			x
cs9c,cs9d*		x	
cs9e,cs9f		x	
cs10a,cs10d		x	
cs10e,cs10f	x		
cs11a,cs11d	x		
cs11e,cs11f	x		

Table 4.5 Proportion of the evolutionary lineages that exhibited size increase, or not. Categories denoted with * are the component parts of the proportion that did not exhibit size increase. This proportion was composed of evolutionary lineage descendants with smaller mean areas and evolutionary lineage ancestor-descendant means areas that were not statistically different

Total number of lineages	21	100%
Size increase	11	52%
No size increase	10	48%
*Size decrease	7	33%
*Same size	3	14%

Between Hennigian descendants

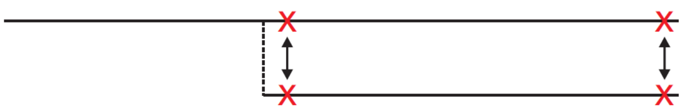


Figure 4.28 A schematic illustrating the pairs of population means (red crosses) that were compared (denoted by the arrows) between the two Hennigian lineage descendants (a continuation of the ancestral lineage and the descended lineage).

Table 4.6 Comparison between the Hennigian lineage pair means across the whole data set categorised by the result (whether they showed an increase in mean area, a decrease in mean area or had mean areas that were statistically indistinguishable).

Between Hennigian descendants sample cods	Mean area increases	Mean area decreases	Mean areas the same
cs1c,cs1e		x	
cs1d,cs1f		x	
cs2c,cs2e		x	
cs2d,cs2f		x	
cs3c,cs3e		x	
cs3d,cs3f	x		
cs4c,cs4e	x		
cs4d,cs4f	x		

cs7c,cs7e	x		
cs7d,cs7f	x		
cs8c,cs8e	x		
cs8d,cs8f	x		
cs9c,cs9e		x	
cs9d,cs9f			x
cs10c,cs10e		x	
cs10d,cs10f	x		
cs11c,cs11e	x		
cs11d,cs11f	x		

Table 4.7 Proportion of the Hennigian descendant pairs that exhibited size increase (between the ancestral form and the descended form), or not. Categories denoted with * are the component parts of the proportion that did not exhibit size increase. This proportion was composed of Hennigian descendants with smaller mean areas and Hennigian lineage ancestor-descendant means areas that were not statistically different

Total number of population comparisons	**18**	**100%**
Size increase	10	56%
No size increase	8	44%
*Size decrease	7	39%
*Same size	1	6%

Oldest ancestor population compared to all post cladogenetic populations

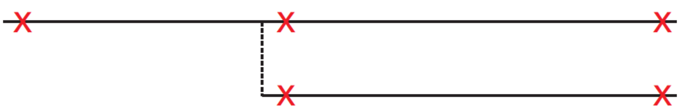


Figure 4.29 A schematic illustrating the oldest ancestral population mean (red cross) that was compared to all post cladogenetic population means.

Table 4.8 Comparison between the oldest ancestral population mean and all post cladogenetic population means across the whole data set, categorised by the result (whether they showed an increase in mean area, a decrease in mean area or had mean areas that were statistically indistinguishable).

Earlier ancestor to post cladogenesis sample codes	**Mean area increases**	**Mean area decreases**	**Mean areas the same**
cs1a,cs1c	x		
cs1a,cs1e		x	
cs1a,cs1d	x		
cs1a,cs1f			x
cs2a,cs2c	x		

cs2a,cs2e			x
cs2a,cs2d	x		
cs2a,cs2f			x
cs3a,cs3c		x	
cs3a,cs3e		x	
cs3a,cs3d		x	
cs3a,cs3f		x	
cs4a,cs4c	x		
cs4a,cs4e	x		
cs4a,cs4d	x		
cs4a,cs4f	x		
cs6a,cs6c	x		
cs6a,cs6d	x		
cs7a,cs7c		x	
cs7a,cs7e		x	
cs7a,cs7d		x	
cs7a,cs7f	x		
cs8a,cs8c			x
cs8a,cs8e	x		
cs8a,cs8d		x	
cs8a,cs8f			x
cs10a,cs10c		x	
cs10a,cs10e		x	
cs10a,cs10d		x	
cs10a,cs10f			x
cs11a,cs11c			x
cs11a,cs11e	x		
cs11a,cs11d	x		
cs11a,cs11f	x		

Table 4.9 Proportion of the oldest ancestor-descendant pairs that exhibited size increase (between the ancestral form and the descended form), or not. Categories denoted with * are the component parts of the proportion that didn't exhibit size increase. This proportion was composed of descendants with smaller mean areas and ancestor-descendant means areas that weren't statistically different

Total number of population comparisons	34	100%
Size increase	15	44%
No size increase	19	56%
*Size decrease	12	35%
*Same size	7	21%

Youngest ancestor population compared to all post cladogenetic populations

Figure 4.30 A schematic illustrating the youngest ancestral population mean (red cross) that was compared to all post cladogenetic population means.

Table 4.10 Comparison between the youngest ancestral population mean and all post cladogenetic population means across the whole data set, categorised by the result (whether they showed an increase in mean area, a decrease in mean area or had mean areas that were statistically indistinguishable).

Later ancestor to post cladogenesis sample codes	Mean area increases	Mean area decreases	Mean areas the same
cs1b,cs1c			x
cs1b,cs1e		x	
cs1b,cs1d			x
cs1b,cs1f		x	
cs2b,cs2c	x		
cs2b,cs2e			x
cs2b,cs2d	x		
cs2b,cs2f			x
cs3b,cs3c			x
cs3b,cs3e	x		
cs3b,cs3d		x	
cs3b,cs3f	x		
cs4b,cs4c			x
cs4b,cs4e	x		
cs4b,cs4d		x	
cs4b,cs4f	x		
cs6b,cs6c		x	
cs6b,cs6d	x		
cs7b,cs7c			x
cs7b,cs7e			x
cs7b,cs7d			x
cs7b,cs7f	x		
cs8b,cs8c			x
cs8b,cs8e	x		
cs8b,cs8d		x	
cs8b,cs8f	x		
cs10b,cs10c		x	
cs10b,cs10e		x	
cs10b,cs10d			x
cs10b,cs10f	x		
cs11b,cs11c		x	
cs11b,cs11e	x		
cs11b,cs11d	x		
cs11b,cs11f	x		

Table 4.11 Proportion of the youngest ancestor-descendant pairs that exhibited size increase (between the ancestral form and the descended form), or not. Categories denoted with * are the component parts of the proportion that did not exhibit size increase. This proportion was composed of descendants with smaller mean areas and Hennigian lineage ancestor-descendant means areas that were not statistically different.

Total number of population comparisons	**34**	**100%**
Size increase	14	41%
No size increase	20	59%
*Size decrease	9	26%
*Same size	11	32%

In all the different comparative methods size increase occurred between 41-52% of the time and chi-squared analysis of all comparative results demonstrates that size change is independent of the five different types of ancestor-descendant evolutionary relationship analyzed (Chi-squared test result of 5.97, critical value: 9.487729. See Appendix 2.3 for analysis).

4.4. Discussion

There have been two significant previous attempts to evaluate body sizes changes within the Cenozoic macroperforate planktonic foraminifera, Schmidt *et al*. (2004*a*) evaluates evolutionary size trends of entire planktic foraminiferal assemblages and Arnold, Kelly & Parker (1995) conducted a literature-based assessment of Cenozoic lineages. Schmidt *et al*. (2004*a*) found that planktonic foraminifera had three stages of size change, between 65-42 Ma body size was small and the period is dominated by 'dwarfs', between 42-14 Ma body size fluctuated moderately and between 14 Ma and the present planktonic foraminifera at lower latitudes were documented to show a significant increase in body size. The data were gathered using an automated system which did not identify the lineages which individual specimens represented so no distinctions could be made as to whether individual lineages became larger or smaller, making Cope's rule un-testable. Arnold, Kelly & Parker (1995) directly addressed Cope's rule and although all lineages throughout the Cenozoic were analysed, size measurements were only taken from the holotype. This is an inherently biased method as holotypes are arbitrarily assigned specimens to a morphospecies and will not adequately represent the natural range of within-taxon size variation, which this analysis has been shown to be very large in some lineages. This study used large populations (100 specimens) from Neogene case studies. This permitted a robust test of Cope's rule, as lineages were selected at random and the phylogenetic affinity of the case studies was generally very good.

When regarded as Hennigian or evolutionary lineages none of the case studies strictly conformed to Cope's rule (all ancestral populations being smaller than the following descendant populations). In some cases one or more of the Hennigian lineages did show an increase in size but it was still less than half of the time (48%). The evolutionary lineages also showed some instances when mean area increased over time, but this occurred only just over half of the time (52%). The strongest support for Cope's rule was between post cladogenetic Hennigian lineage descendants, an increase in mean area was demonstrated when contemporaneous ancestral lineages were compared, but this only occurred just over half of the time (56%) and in many instances descendant lineages were founded at smaller size than the later ancestral population (x^b). The support for Cope's rule was weakest when comparing earlier and later ancestral populations with the post cladogenetic populations. In these situations mean area only increased 44% and 41% of the time for the earlier ancestor and later ancestor comparisons respectively. The lower proportion of size increase between the later ancestor population (x^b in figure 4.1B) and following descendant population (x^c in Figure 4.1B) is likely due to the how close the populations are in time. This result suggests that cladogenesis does not have a significant affect upon ancestor size as 6 out of the 8 pre- and post-cladogenetic ancestral lineage populations (x^b-x^c) were not significantly different from each other.

One of the largest empirical studies that has addressed Cope's rule was conducted by Jablonski (1997). He took 6000 size measurements from approximately 1000 different species of North American molluscs and Cope's rule was rejected. The study found that there was increase in body size variance overtime, with an equal proportion of species that increased in size, decreased in size and exhibited no size change at all. This is not congruent with the findings of this study. A greater proportion of lineages do exhibit an increase in mean area, than become smaller or stay the same size. The "no increase" proportion can be divided into two groups: descendant populations that have same mean area as the ancestral population, and descendant populations that show a decrease in mean size compared to the ancestral population. The former has a proportional range of 6-32% and the latter a proportional range of 28-39%.

It appears that Neogene macroperforate planktonic foraminifera do not support Cope's rule, but there are a number of confounding factors that may affect the ability to pick up size related trends in this group, these are discussed as follows.

Pre-extinction dwarfing

It has been proposed that planktonic foraminifera exhibit a phenomenon termed "Pre-extinction dwarfing" (Wade & Olsson, 2009) when species populations exhibit a size decrease prior to extinction. This tendency may have accounted for some of the decrease in mean area towards the end of lineages that became extinct. There were only three terminal lineages that were not extant in the data set, T36 'multicamerata', T356 'woodi.apertura' and T355 'nepenthes'. The first two showed no change in mean size between ancestor and descendant populations and latter does show a decrease in mean area. As so few lineages are sampled close to their extinction it is not possible to suggest any trend towards size decrease immediately prior to extinction and analysis of further terminal lineages may illustrate if this trend is consistent for Cenozoic macroperforate planktonic foraminifera.

Nutritional variance and initial body size

Larger species have a larger range of size variation than smaller species, as can be seen in the initial results by comparing mean area and respective standard deviations (Table 4.1). This increase in variance probably reflects the nature of planktonic foraminifer growth which occurs by the incremental addition of chambers throughout life (Hemleben *et al.*, 1989). The addition of chambers is controlled principally by nutrition and when better fed in cultured environments planktonic foraminifera will grow more chambers (Hemleben *et al.*, 1989). As each successive chamber is bigger than the previous, when more chambers are added size will increase exponentially. A positive feedback may arise through this mechanism whereby bigger individuals may be more effective predators, permitting greater food consumption resulting in an associated increase in number of chambers and therefore, test size. This bias could only be addressed by knowing how well nourished an individual specimen may have and although there are proxies available for determining the fertility of the oceans and therefore giving a possible estimate of available food resource there is no way to determine whether an individual specimen took advantage of those available resources. This effect may also be exacerbated by individuals being founded at larger size, some individuals may have had a larger proloculus (initial chamber) than others of the same species. It is only possible to know how large the proloculus was if it is still visible in the adult stages or by destroying the tests of specimens where the proloculus is hidden. As so few of the case studies included lineages where the proloculus was visible it was not possible to compare their initial sizes. Consequently it is not possible to de-convolve intra-specific size variation as a product evolutionary trends, nutritional variability or initial founding size.

Sample location variance

As the case studies were chosen from a list of all possible lineages the deep sea sediments that were analyzed were taken from four distinctly different geographic provinces, the Pacific, Atlantic, Indian and Southern Oceans. As a consequence there may be size related biases due to geographic province; Schmidt *et al.* (2004*a*) demonstrate that differences in mean body size of populations may be correlated with latitude. High latitude (sub-polar and temperate) and low latitude (sub-tropical and tropical) populations were compared and a strong increase in mean body size was observed from 14 myr to the present in the low latitude populations only. This change in body size as a product of environment will reflect whether an individual or populations are optimally adapted to their environment conditions; in particular temperature, and when this may not be the case body size will diminish (Schmidt *et al.*, 2004*a*). Consequently size related biases may due to geographic province and this bias cannot be disentangled without comparative studies of size change at different sites. In the optimum situation all lineages would be collected from the same geographic site, and preferably duplicated between sites, but this was not possible as not all species are captured in ocean sediments at the required times. In spite of these limitations the planktonic foraminifera fossil record is still an exceptional resource and there are no other groups with such a well defined phylogenetic framework throughout the Cenozoic that would permit a better sampling resolution.

Sample size and timing

At present the analysis only includes randomly selected lineages from the Neogene, this temporal restriction means that a large proportion of the clade has been omitted and importantly the early part of the evolutionary history of the group. Consequently there are significant changes in environment, such as the transition between the greenhouse conditions of the Paleogene and the prevailing icehouse conditions of the Neogene, until further sampling has been completed it will be difficult to make robust interpretations of the influence of environmental change over the patterns of size change. Sampling only the Neogene, due to time constraints, may also bias the data as many of the terminal lineages sampled are extant and the future of their size trajectory is unknown. The weakest relationships analyzed were the populations immediately surrounding cladogenesis. Ocean sediments are sub-divided chronologically by biozones, the top and bottom of a biozone is well defined, but the absolute age of sediments from within a biozone is not precise. Consequently samples that are temporally close together and within a biozone are most likely to have error relating to their age, than samples that are at opposite ends of lineages.

4.5. Conclusions

The randomly selected Neogene macroperforate planktonic foraminifera case studies analyzed in this chapter do not support Cope's rule. When averaged out over all the different comparative methods, mean size only increased between ancestor and descendant pairs 48% of the time. It appears that giving rise to a new species has little effect on evolutionary lineages of planktonic foraminifera, with most pre- and post-cladogenetic populations having a statistically indistinguishable mean area.

The phylogenetic affinity of *T. truncatulinoides* and *T cavernula* requires further attention, detailed morphometric and genetic work is needed to better understand the nature of this relationship.

To achieve a more robust appreciation for size related trends in macroperforate planktonic foraminifera sampling of the entire Cenozoic will need to be completed. It is anticipated that there will be an observed increase in overall assemblage size from the post K/T 'dwarfs' to the larger modern faunas as detailed in Schmidt *et al*. (2004*a*), but whether Cope's rule is true for the whole Cenozoic depends on the outcomes of the remaining randomly selected evolutionary lineages.

5. Conclusions and prospects

5.1 Phylogenies

The phylogenies presented in Chapter 2 are a state-of-the-art synthesis of the Cenozoic macroperforate planktonic foraminifera. The graphical presentation of these composite phylogenies allows for an immediate appreciation of the evolutionary history of this exceptional fossil group. The phylogenies provide the opportunity to describe the evolution of the group and to analyse macroevolutionary dynamics statistically.

The phylogenetic relationships of Paleocene and Eocene macroperforate planktonic foraminifera are likely to be the most robust due to the recent publication of Atlases by the Paleogene working group (Olsson *et al*., 1999; Pearson *et al*., 2006). A revision of the Neogene is required with the last synthesis being conducted over 25 years ago (Kennett & Srinivasan, 1983), and the Paleogene Working Group is currently preparing the *Atlas of Oligocene Planktonic Foraminifera*. As more detailed morphometric and genetic analysis are produced it is anticipated that some of the relationships detailed in the phylogenies may change.

Initial comparison of the phylogenies presented in this thesis with molecular phylogenies illustrates a general agreement between genetic and fossil phylogenies, despite some discrepancies (as detailed in section 3.3.2) which require further attention.

Analysis of completeness of the phylogenies illustrates that planktonic foraminifera have a species level fossil record at least as good as the best preserved macro-invertebrate groups (Foot & Sepkoski, 1999) with a mean completeness of 83.4% per species per one million years. This unparalleled fossil record makes planktonic foraminifera a model system for micro- and macroevolutionary studies.

5.2 Macroevolution

A qualitative assessment of the macroevolution of Cenozoic macroperforate planktonic foraminifera illustrates that after rapid environmental change, such as the K/Pg and Miocene/Pliocene boundary, there is an increase in diversification which may indicate an expansion into newly-available niche space. The qualitative assessment also demonstrates that periods of extreme environmental stress, such as the Paleocene-Eocene thermal maximum and the Eocene-Oligocene boundary, are marked by peaks of extinction.

Statistical analysis of the evolution of the group has demonstrated the importance of incorporating information on species ecologies when trying to disentangle biotic and abiotic evolutionary drivers. This approach demonstrates that extinction is more strongly influenced by changes in the environment, while the interaction between contemporaneous species exerts more control over speciation (Ezard *et al.*, 2011). The statistical analysis also illustrates that species are more likely to give rise to new species when they are “younger”, (fitting with the early burst model of evolution) and disputes ‘Van Valen’s Law of Constant Extinction’ (Van Valen, 1973) as species within this clade are more likely to become extinct if they are “older” (Ezard *et al*., 2011).

Permitting different species to respond differently to environmental change and diversity dependence as part of distinct ecological groups gives the strongest model support. This approach highlights the importance of not treating clades as homogeneous populations when conducting macroevolutionary research (Ezard *et a*l., 2011).

5.3 Cope’s rule

The analysis of the randomly selected Neogene evolutionary lineages has demonstrated that the mean area of ancestor-descendant populations macroperforate planktonic increased in size 48.2% of the time when averaged across all phylogenetic comparative methods.

Hennigian and evolutionary lineages showed an increase in mean area 48% and 56% of the time respectively. The remaining proportion was variably composed of ancestor-descendant populations that showed a decrease in mean area or no significant change in mean size.

The most robust method for testing Cope’s rule in planktonic foraminifera is to compare ancestor descendant populations of evolutionary lineages as these are the least subject to temporal biases.

5.4 Prospects

The phylogenetic and taxonomic revision of the Paleogene will need to be followed by a similar treatment of the Neogene, with a working group of taxonomic experts deciphering the details of the evolutionary relationships of the last 23.8 million years. The Neogene, which includes extant taxa, provides the opportunity to combine molecular and fossil data to produce the most robust phylogenetic hypotheses possible.

The phylogenies will provide a robust framework for many micro- and macroevolutionary studies for example; how niche space is explored by species, what drives interspecific competition and how extrinsic factors influence morphological change and the dynamics of community structure. The trees will also provide a fossil derived phylogenetic hypothesis against which molecular phylogenies can be tested.

The Cope’s rule analysis will be expanded to include all randomly sampled lineages from the whole Cenozoic with the intention of detecting size trends in macroperforate planktonic foraminifera throughout the last 65 million years.

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Appendices

Appendix 1. Age control of sample material for selected evolutionary lineages

Sites 872C and 871A ODP Leg 144.

The following three tables have been taken directly from Pearson, P.N. (1995) Planktonic foraminifera biostratigraphy and the development of pelagic caps on guyots in the Marshall Islands. In :Haggerty, J.A., Premoli Suva, L, Rack, R, and McNutt, M.K. (Eds.), *Proceedings of the Ocean Drilling Program, Scientific Results,* Vol. 144

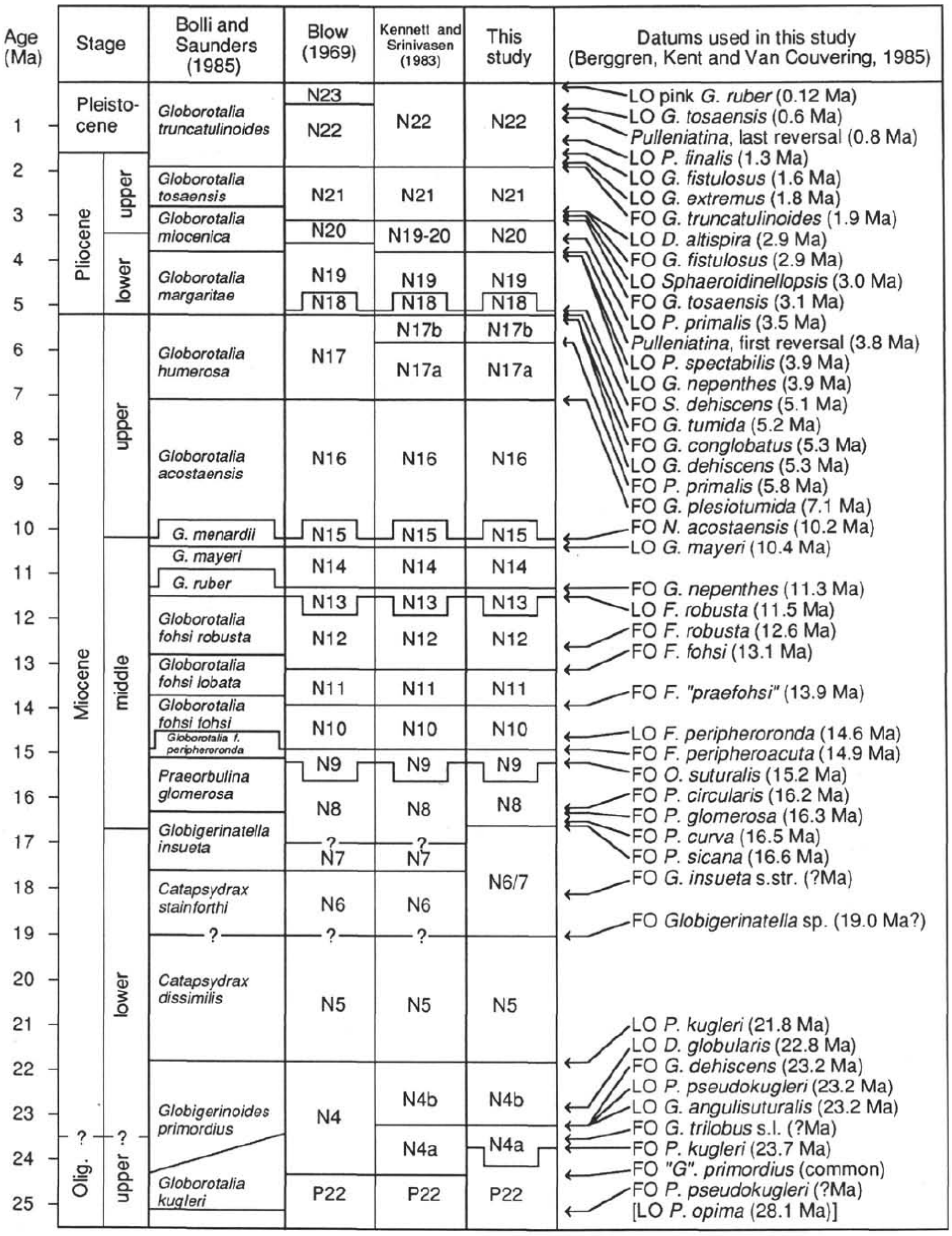

Figure 2. Zonal scheme and list of biostratigraphic datums used in this study, in comparison with standard tropical zonations for planktonic foraminifers.

Table 2. Planktonic foraminifer datums in Hole 871A and their stratigraphic positions.

Datum		Stratigraphic position	Age (Ma)	Core, section, interval (cm) Top	Bottom	Depth (mbsf)	Interpolated depth (mbsf)
LO	Pink *Globigerinoides ruber*		0.12	1H-1, 124–126	1H-2, 59–61	1.24–2.09	1.66
LO	*Globorotalia tosaensis*		0.6	1H-CC	2H-1, 60–62	7.30–8.09	7.70
	Pulleniatina, last coiling reversal		0.8	1H-CC	2H-1, 60–62	7.30–8.09	7.70
FO	*Pulleniatina finalis*		1.3	2H-6, 60–62	2H-CC	15.59–16.60	16.10
LO	*Globigerinoides fistulosus*	Pliocene/Pleistocene	1.6	2H-CC	3H-1, 60–62	17.00–17.60	17.30
LO	*Globigerinoides extremus*		1.8	2H-CC	3H-1, 60–62	17.00–17.60	17.30
FO	*Globorotalia truncatulinoides*	Base N22/Top N21	1.9	3H-2, 60–62	3H-2, 123–125	19.10–19.73	19.42
LO	*Dentoglobigerina altispira*		2.9	3H-2, 123–125	3H-3, 60–62	19.73–20.60	20.16
FO	*Globigerinoides fistulosus*		2.9	3H-2, 123–125	3H-3, 60–62	19.73–20.60	20.16
LO	*Sphaeroidinellopsis*		3.0	3H-2, 123–125	3H-3, 60–62	19.73–20.60	20.16
FO	*Globorotalia tosaensis*	Base N21/Top N20	3.1	3H-2, 123–125	3H-3, 60–62	19.73–20.60	20.16
LO	*Pulleniatina primalis*	Base N20/Top N19	3.5	3H-3, 123–125	3H-4, 60–62	21.23–22.10	21.66
	Pulleniatina, first coiling reversal		3.8	3H-3, 123–125	3H-4, 60–62	21.23–22.10	21.66
LO	*Globoturborotalita nepenthes*		3.9	3H-3, 123–125	3H-4, 60–62	21.23–22.10	21.66
FO	*Sphaeroidinalla dehiscens*	Base N19/Top N18	5.1	3H-3, 123–125	3H-4, 60–62	21.23–22.10	21.66
FO	*Globorotalia tumida*	Base N18/Top N17B	5.2	3H-3, 123–125	3H-4, 60–62	21.23–22.10	21.66
FO	*Globigerinoides conglobatus*		5.3	3H-3, 123–125	3H-4, 60–62	21.23–22.10	21.66
LO	*Globoquadrina dehiscens*		5.3	3H-3, 123–125	3H-4, 60–62	21.23–22.10	21.66
FO	*Pulleniatina primalis*	Base N17B/Top N17A	5.8	3H-4, 123–125	3H-5, 60–62	22.73–23.60	23.16
FO	*Globorotalia plesiotumida*	Base N17A/Top N16	7.1	3H-CC	4H-1, 126–128	25.70–27.74	26.72
FO	*Neogloboquadrina acostaensis*	Base N16/Top N15	10.2	3H-CC	4H-1, 126–128	25.70–27.74	26.72
LO	*Paragloborotalia mayeri*	Base N15/Top N14	10.4	3H-CC	4H-1, 126–128	25.70–27.74	26.72
FO	*Globoturborotalita nepenthes*	Base N14/Top N13	11.3	3H-CC	4H-1, 126–128	25.70–27.74	26.72
LO	*Fohsella*	Base N13/Top N12	11.5	3H-CC	4H-1, 126–128	25.70–27,74	26.72
FO	*Fohsella robusta*		12.6	5H-3, 59–61	5H-4, 59–61	39.59–41.09	40.34
FO	*Fohsella fohsi*	Base N12/Top N11	13.1	6H-6, 60–62	6H-CC	54.20–55.00	54.60
FO	*Fohsella praefohsi*	Base N11/Top N10	13.9	6H-6, 60–62	6H-CC	54.20–55.00	54.60
LO	*Fohsella peripheroronda*		14.6	6H-CC	7H-1, 59–61	55.00–55.59	55.30
FO	*Fohsella peripheroacuta*	Base N10/Top N9	14.9	7H-4, 59–61	7H-5, 59–61	60.09–61.59	60.84
FO	*Orbulina*	Base N9/Top N8	15.2	7H-CC	8H-1, 59–61	64.50–65.09	64.80
FO	*Praeorbulina circularis*		16.2	8H-1, 59–61	8H-2, 59–61	65.09–66.59	65.84
FO	*Praeorbulina glomerosa*		16.3	8H-3, 59–61	8H-4, 59–61	68.09–69.59	68.84
FO	*Praeorbulina curva*		16.5	8H-CC	9H-1, 59–61	74.00–74.59	74.30
FO	*Praeorbulina sicana*	Base N8/Top N7	16.6	9H-5, 59–61	9H-CC	81.80–83.50	82.65
FO	*Globigerinatella* sp.	Base N6/Top N5	19.0	13H–CC	14H-1, 60–62	121.50–122.10	121.80
FO	*Globoquadrina dehiscens*		23.2	15H-5, 59–61	15H-6, 59–61	137.09–138.59	137.84
FO	*Globigerinoides trilobus*	Base N4B/Top N4A	23.5	15H-CC	Bottom	139.20–139.50	>139.20

Note: FO = first occurrence and LO = last occurrence.

Table 5. Planktonic foraminifer datums in Hole 872C and their stratigraphic positions.

Datum		Stratigraphic position	Age (Ma)	Core, section, interval (cm) Top	Bottom	Depth (mbsf)	Interpolated depth (mbsf)
LO	Pink *Globigerinoides ruber*		0.12	Core top	1H-1, 58–60	0.0–0.58	<0.58
LO	*Globorotalia tosaensis*		0.6	1H-3, 124–126	1H-4, 58–60	3.52–4.29	3.90
	Pulleniatina, last coiling reversal		0.8	1H-3, 124–126	1H-4, 58–60	3.52–4.29	3.90
FO	*Pulleniatina finalis*		1.3	2H-1, 58–60	2H-2, 58–60	9.58–10.54	10.06
LO	*Globigerinoides fistulosus*	Pliocene/Pleistocene	1.6	1H-6, 58–60	1H-CC	7.06–7.60	7.33
LO	*Globigerinoides extremus*		1.8	1H-CC	2H-1, 58–60	7.60–9.58	8.59
FO	*Globorotalia truncatulinoides*	Base N22/Top N21	1.9	2H-1, 58–60	2H-2, 58–60	9.58–10.54	10.06
LO	*Dentoglobigerina altispira*		2.9	2H-CC	3H-1, 59–61	17.00–19.09	18.04
FO	*Globigerinoides fistulosus*		2.9	3H-1, 59–61	3H-2, 59–61	19.09–20.15	19.62
LO	*Sphaerodinellopsis*		3.0	2H-CC	3H-1, 59–61	17.00–19.09	18.04
FO	*Globorotalia tosaensis*	Base N21/Top N20	3.1	2H-CC	3H-1, 59–61	17.00–19.09	18.04
LO	*Pulleniatina primalis*		3.5	3H-4, 59–61	3H-4, 118–120	22.66–23.25	22.95
	Pulleniatina, first coiling reversal	Base N20/Top N19	3.8	3H-4, 118–120	3H-5, 59–61	23.25–23.97	23.61
LO	*Pulleniatina spectabilis*		3.9	3H-5, 59–61	3H-5, 118–120	23.97–24.56	24.26
LO	*Globoturborotalita nepenthes*		3.9	3H-5, 118–120	3H-6, 59–61	24.56–25.29	24.92
FO	*Sphaeroidinella dehiscens*	Base N19/Top N18	5.1	3H-6, 59–61	3H-CC	25.29–26.90	26.10
FO	*Pulleniatina spectabilis*		5.2	3H-6, 59–61	3H-CC	25.29–26.90	26.10
FO	*Globorotalia tumida*	Base N18/Top N17B	5.2	3H-CC	4H-1, 59–61	26.90–28.59	27.74
FO	*Globigerinoides conglobatus*		5.3	4H-3, 59–61	4H-4, 59–61	30.87–32.20	31.54
LO	*Globoquadrina dehiscens*		5.3	4H-3, 59–61	4H-4, 59–61	30.87–32.20	31.54
FO	*Pulleniatina primalis*	Base N17B/Top N17A	5.8	4H-6, 59–61	4H-CC	34.71–35.30	35.06
FO	*Globorotalia plesiotumida*	Base N17A/Top N16	7.1	4H-CC	5H-1, 14–16	35.40–37.64	36.52
FO	*Neogloboquadrina acostaensis*	Base N16/Top N15	10.2	5H-3, 14–16	5H-4, 14–16	39.65–40.91	40.28
LO	*Paragloborotalia mayeri*	Base N15/Top N14	10.4	5H-CC	6H-1, 20–22	44.20–47.20	45.70
FO	*Globoturborotalita nepenthes*	Base N14/Top N13	11.3	5H-CC	6H-1, 20–22	44.20–47.20	45.70
LO	*Fohsella*	Base N13/Top N12	11.5	7H-3, 20–22	7H-4, 20–22	59.01–60.31	59.66
FO	*Fohsella robusta*		12.6	7H-CC	8H-1, 20–22	64.30–66.20	65.25
FO	*Fohsella fohsi*	Base N12/Top N11	13.1	8H-3, 20–22	8H-4, 20–22	68.51–69.81	69.16
FO	*Fohsella praefohsi*	Base N11/Top N10	13.9	8H-6, 20–22	8H-CC	72.47–74.00	73.24
LO	*Fohsella peripheroronda*		14.6	8H-CC	9H-1, 20–22	74.00–75.70	74.85
FO	*Fohsella peripheroacuta*	Base N10/Top N9	14.9	9H-6, 20–22	9H-7, 20–22	82.33–83.40	82.86
FO	*Orbulina*	Base N9/Top N8	15.2	9H-6, 20–22	9H-7, 20–22	82.33–83.40	82.86
FO	*Praeorbulina circularis*		16.2	9H-6, 20–22	9H-7, 20–22	82.33–83.40	82.86
FO	*Praeorbulina sicana*	Base N8/Top N7	16.6	10H-CC	11H-1, 20–22	93.80–94.70	94.25
FO	*Globigerinatella* sp.	Base N6/Top N5	19.0	12H-1, 20–22	12H-2, 20–22	104.20–105.70	104.95
LO	*Paragloborotalia kugleri*	Base N5/Top N4B	21.8	13H-3, 20–22	13H-4, 20–22	108.68–110.00	109.34
LO	*Dentoglobigerina globularis*		22.8	13H-4, 20–22	13H-5, 20–22	110.00–111.34	110.67
FO	*Globoquadrina dehiscens*	Base N4B/Top N4A	23.2	13H-5, 20–22	13H-6, 20–22	111.34–112.64	111.99
LO	*Paragloborotalia pseudokugleri*		23.2	13H-5, 20–22	13H-6, 20–22	111.34–112.64	111.99
LO	"*Globigerina*" *angulisuturalis*		23.2	14H-CC	15H-1, 20–22	123.70–125.20	124.45
FO	*Paragloborotalia kugleri*	Base N4A/Top P22	23.7	14H-CC	15H-1, 20–22	123.70–125.20	124.45
FO	"*G.*" *primordius* (common)		24.3	17X-CC	Bottom	141.60–141.70	>141.60

Note: FO = first occurrence and LO = last occurrence.

Site 925A

The following three table have been taken directly from Chassion, W. P. & Pearson, P. N. (1997). Planktonic foraminifera biostratigraphy at Site 925: Middle Miocene-Pleistocene. In: Shackleton, N.J., Curry, W.B., Richter, C., and Bralower, T.J. (Eds.) *Proceedings of the Ocean Drilling Program, Scientific Results*, Vol. 154

Table 2. Revised absolute ages for planktonic foraminiferal datums.

Planktonic foraminifer age events in Hole 925B	Core, section, interval (cm) Top	Core, section, interval (cm) Bottom	Depth (mbsf) Top	Depth (mbsf) Bottom	Depth (mbsf) Mean	Ceara Rise age (Ma)	Published age (Ma)
FO *P. finalis*	7H-6, 68–70	8H-1, 65–67	60.19	62.16	61.18	2.04 ± 0.03	1.4
LO *Gs. fistulosus*	7H-3, 65–67	7H-4, 68–70	55.66	57.19	56.43	1.88 ± 0.03	1.7
LO *Gt. apertura*	6H-5, 55–57	6H-6, 55–57	49.06	50.56	49.81	1.64 ± 0.03	1.9
LO *Gs. extremus*	7H-5, 68–70	7H-6, 68–70	58.69	60.19	59.44	1.98 ± 0.03	1.9
FO *T. truncatulinoides*	7H-4, 68–70	7H-5, 65–67	57.19	58.66	57.93	1.92 ± 0.03	2.0
LO *M. exilis*	8H-1, 65–67	8H-2, 65–67	62.15	63.65	62.90	2.09 ± 0.02	2.2
LO *M. miocenica*	8H-7, 53–55	9H-1, 65–67	71.04	71.66	71.35	2.38 ± 0.02	2.3
Re-appearance, *Pulleniatina*	8H-5, 53–55	8H-6, 65–67	68.15	69.65	68.90	2.26 ± 0.03	2.3
LO *Gt. woodi*	8H-6, 65–67	8H-7, 53–55	69.66	71.04	70.35	2.33 ± 0.02	2.3
LO *Gt. decoraperta*	10H-1, 65–67	10H-2, 65–67	81.16	82.66	81.91	2.75 ± 0.03	2.6
LO *M. pertenuis*	8H-6, 65–67	8H-7, 53–55	69.65	71.05	70.35	2.33 ± 0.02	2.6
LO *D. altispira*	10H-7, 58–60	11H-1, 65–67	90.09	90.66	90.38	3.11 ± 0.02	3.0
LO *M. multicamerata*	10H-6, 65–67	10H-7, 58–60	88.66	90.09	89.38	3.10 ± 0.03	3.0
LO *Ss. seminulina*	10H-7, 58–60	11H-1, 65–67	90.09	90.66	90.38	3.11 ± 0.02	3.1
Disappearance, *Pulleniatina*	12H-1, 54–56	12H-2, 69–71	100.05	101.7	100.88	3.41 ± 0.03	3.5
FO *M. pertenuis*	12H-3, 65–67	12H-4, 54–56	103.16	104.55	103.86	3.52 ± 0.03	3.5
FO *M. miocenica*	12H-CC	13H-1, 66–68	109.11	109.66	109.39	3.77 ± 0.02	3.6
LO *H. margaritae*	13H-2, 66–68	13H-3, 60–62	111.17	112.61	111.89	3.85 ± 0.03	3.6
Pulleniatina, sin. to dex.	13H-7, 51–53	14H-1, 65–67	118.52	119.16	118.84	4.08 ± 0.03	4.0
LO *Gt. nepenthes*	14H-7, 10–12	15H-1, 10–12	127.61	128.11	127.86	4.39 ± 0.01	4.3
LO *Gr. plesiotumida*	12H-7, 51–53	13H-1, 66–68	109.02	109.67	109.35	3.77 ± 0.02	4.4
FO *T. crassaformis* s.l.	14H-5, 65–67	14H-6, 65–67	125.15	126.65	125.90	4.31 ± 0.04	4.7
LO *H. cibaoensis*	11H-4, 65–67	11H-5, 65–67	95.15	96.65	95.90	3.22 ± 0.03	5.0
LO *N. acostaensis*	6H-4, 55–57	6H-5, 55–57	47.55	49.05	48.30	1.58 ± 0.03	5.1
LO *Gq. baroemoenensis*	11H-4, 65–67	11H-5, 65–67	95.15	96.65	95.90	3.22 ± 0.03	5.4
FO *S. dehiscens*	17H-4, 65–67	17H-5, 65–67	152.16	153.66	152.91	5.54 ± 0.04	5.6
FO *Gr. tumida*	18H-1, 66–68	18H-2, 66–68	157.17	158.67	157.92	5.82 ± 0.04	5.9
FO *H. margaritae*	18H-5, 66–68	18H-6, 66–68	163.17	164.67	163.92	6.09 ± 0.03	6.2
FO *H. cibaoensis*	26H-5, 65–67	26H-6, 65–67	239.15	240.65	239.90	9.44 ± 0.05	7.7
FO *C. nitida*	24H-7, 65–67	25H-2, 65–67	223.16	225.16	224.16	8.44 ± 0.04	8.0
FO *Gs. extremus*	25H-3, 65–67	25H-4, 62–64	226.66	228.13	227.40	8.58 ± 0.03	8.0
FO *Gr. plesiotumida*	25H-3, 65–67	25H-4, 62–64	226.66	228.13	227.40	8.58 ± 0.03	8.2
FO *N. acostaensis*	27H-2, 65–67	27H-3, 65–67	244.16	245.66	244.91	9.82 ± 0.06	10.0
LO *P. mayeri*	28H-7, 65–67	29H-1, 65–67	261.16	261.66	261.41	10.49 ± 0.02	10.3
FO *Gt. apertura*	29H-6, 65–67	30H-2, 65–67	269.16	272.66	270.91	11.19 ± 0.13	10.8
FO *G. decoraperta*	30H-4, 65–67	30H-5, 65–67	275.65	277.15	276.40	11.46 ± 0.04	11.2
FO *Gt. nepenthes*	29H-7, 65–67	30H-1, 65–67	270.66	271.16	270.91	11.19 ± 0.02	11.4
LO *F. fohsi* s.l.	30H-6, 65–67	31H-1, 65–68	278.66	280.66	279.66	11.68 ± 0.15	11.8
FO *Gr. lenguaensis*	32H-4, 65–67	32H-5, 66–68	294.66	296.17	295.42	12.85 ± 0.05	12.3
FO *F. robusta*	32H-7, 65–67	33H-1, 65–67	299.16	299.66	299.41	13.18 ± 0.02	12.7
FO *F. fohsi*	33H-4, 65–67	33H-5, 65–67	304.16	305.66	304.91	13.42 ± 0.04	13.5

Note: Published absolute ages are those of Berggren et al. (1985), converted to the Leg 154 time scale, which uses the Cande and Kent (1992) revision of the global polarity time scale.

Site 1137A

Age control produced by Dr Helen Coxall for site 1137A from ODP Leg 183 (Kerguelen Plateau, Southern Ocean).

Depth (mbsf)	1137A	Sample	depth (mbsf) (CC, no error	Nanno datum event	Nanno datum age	Foram datum event	Foram datum age	**Age model age 1 (Myr, forams hole data set)**
0.0-9.5	1R	CC	9.50	Top P. perplexa (perplexa in this sample)	3.8			**9.3**

9.5-18.6	2R	CC	18.60			Top N. nympha in 2CC not 1CC	10.1	**10.5**
18.6-27.6	3R	CC	27.60					**11.7**
27.6-36.8	4R	CC	36.80					**12.9**
36.8-46.0	5R	CC	46.00	Top Cyclicargolithus floridanus/abisectus (in 5CC not 4CC	11.4	Base N. nympha in 4CC not 5CC	13.4	**14.2**
46.0-55.2	6R	CC	55.20					**15.4**
55.2-64.8	7R	CC	64.80	Base C. macintyrei In 7CC not 8CC	17.8	Last downhole occurrence of Gl. miozea in 7CC not 8CC	16.7	**16.7**
64.8-74.5	8R	CC	74.50					**18.0**
74.5-84.1	9R	CC	84.10			Base P. incognita in 9CC not 11CC	21.6	**19.2**
84.1-93.7	10R	CC	93.70					**20.5**
93.7-103.3	11R	CC	103.30					**21.8**
103.3-112.9	12R	CC	112.90	Top R. bisecta in 12CC not 13CC	23.9			**23.0**
112.9-122.6	13R	CC	122.60					**24.3**
122.6-132.2	14R	CC	132.20	Top C. altus in 14CC not 15CC	26.1	Top G. euapertura in 14CC not 13CC	23.8	**25.6**
132.2-141.8	15R	CC	141.80					**26.9**
141.8-151.4	16R	CC	151.40			HCO C. cubensis in 16CC not 15CC	28.5	**28.2**
151.4-161.0	17R	CC	161.00					**29.4**

161.0-170.7	18R	CC	170.70	Top I. recurvus not in 18CC in 19CC	32	Top S. angiporoides in 18CC not 17CC	30	**30.7**
170.7-180.3	19R	CC	180.30					**32.0**
180.3-189.9	20R	CC	189.90					**33.3**
	183-1137A-21R-1, 75-79 cm		190.65			Top G. index in 21R-1, 75-79 not 20CC	34.3	**33.4**
189.9-199.5	21R	CC	199.50					**34.5**
199.5-209.1	22R	CC	209.10					**35.8**

GLOW

The following is the biostratigraphy report taken from the GLOW cruise report which provided the age dates for the GLOW samples used in the random sampling.

Biostratigraphy

We recovered a large number of Holocene or Pleistocene samples with beautiful tropical assemblages. These will be used for isotopic, taphonomic and taxonomic studies.
Holocene foraminifera from the GLOW 7 box core. In addition, the following four sites provided useful 'fossil' age constraints:
GLOW 4 (-8.893 S; 41.493 E): A box core was taken on the north flank of the Tanzania Channel, water depth 3,170m. An assemblage from the bottom of the box core (depth ~29 cm) was assigned to upper Miocene Biozone M13b/M14 undifferentiated (Age: 5.82 – 6.2 Ma). This interval is recognized by the presence of *Globorotalia plesiotumida* and *Globigerinoides conglobatus* in the absence of *Globoquadrina dehiscens Globorotalia tumida* and *G. lenguaensis*. Additional marker species present include *Sphaeroidinellopsis seminulina* (in the absence of *Sphaeroidinella* spp.),

Globoturborotalita nepenthes, *Dentoglobigerina altispira*, *Pulleniatina primalis*, *Globigerinoides extremus*, and *Globigerinoides conglobatus*)

GLOW 10 (-9.240; 40.350): A box core was taken at the western end of the 'Seagap' high, water depth 2,762 m. The core penetrated to 24 cm and additional material was found adhering to the base of the coring apparatus. The top of the box core was probably Holocene (including *Globigerinella adamsi*, *Pulleniatina finalis*, and a typical Pleistocene to Recent assemblage). However, sample from the base of the box core (depth ~24 cm) and the material adhering to the outside, were assigned to upper Miocene Sub-biozone M13a (Age: 8.58-9.82 Ma). This interval is recognized by the presence of *Globorotalia merotumida* in the absence of *G. plesiotumida* and the presence of *Neogloboquadrina acostaensis*. Additional marker species present include *Globoturborotalita nepenthes*, *Sphaeroidinellopsis seminulina*, *Globorotalia praemenardii*, *Globoquadrina dehiscens*, and *Dentoglobigerina altispira.* There was also some possible reworked material from the lower and/or middle Miocene, including rare specimens of *Globigerinatella insueta* and *Paragloborotalia mayeri*. The samples contain abundant shallow water debris such as coral fragments and sand with a small piece of amber, and a relatively high abundance of benthic foraminifera.

GLOW 13 (-10.016; 41.697): A box core and two piston cores (A and B) were taken at the south flank of the 'GLOW deep' channel at a depth of 2,451 m. Age determinations were made from the base of the box core (~33 cm) and the core-catcher of Piston Core B (3.19 m). (Piston Core A failed to recover any sediment.) Biostratigraphic assignments from the box core and Piston Core B agree in placing the samples in the lowermost part of Biozone PL1 (Age 5.54-5.82 Ma) which corresponds to the uppermost Miocene. This interval is recognized by the presence of *Globorotalia tumida* and *Sphaeroidinellopsis seminulina* in the absence of *Sphaeroidinella*. Additional marker species present include *Menardella limbata, Globigerinella siphonifera, Globoturborotalia nepenthes, Dentoglobigerina altispira* and *Pulleniatina primalis*. A single specimen of the short-ranging species *Pulleniatina praespectalibilis* supports the age assignment and may be the first record of this species from the Indian Ocean. Uppermost Miocene planktonic foraminifera from GLOW 13

GLOW 22 (-9.848; 40.579; depth 1,857m): A box core (~21 cm) and a piston core were taken at an area of outcropping reflectors east of the Kitunda block. Biostratigraphic age assignments from the base of the box core and base of the piston core agree in placing the samples in Zone PL1 because of the overlapping presence of *Globoturborotalita* *nepenthes* and *Globorotalia tumida*. The presence of *S. kochi* and *Sphaeroidinella dehiscens* and absence of *Globoquadrina dehiscens* help constrain the age to 4.39-5.49 Ma. A slight difference in assemblages was noted in that the box core contained better developed *P. praespectabilis* and specimens referable to *G. fistulosus*. This is an anomalously early occurrence for *G. fistulosus*, but the range of that species has been controversial.

Reference

Wade, B.S., Pearson, P.N., and Berggren, W.A. In prep. Summary and revision of Cenozoic tropical planktonic foraminiferal events. Journal of Foraminiferal Research.

Appendix 2. Data analysis of randomly selected Neogene lineages

The following data analysis was performed in the statistical programming environment R, the data are given as direct outputs from the package with annotations by the author in bold.

2.1 r^2 of Neogene means area against time

```
> timeSize<-read.table("D:\\R\\timeSize.txt")
> attach(timeSize)
> timeSize
   time meanSize
1  10.3 112784.0
2   3.8 147969.0
3   3.8 146635.7
4   0.0 156627.0
5   3.8  88179.6
6   0.3 124435.0
7  22.5  75334.5
8  17.0  72016.3
9  17.0 147773.9
10  3.3 247720.7
11 17.0  75375.9
12  0.0  77105.9
13 14.3  74877.2
14  2.0  24269.0
15  2.0  28486.9
16  0.0  33677.6
17  2.0  24631.9
18  0.0  21946.3
19 12.1  19606.3
20 11.5  45778.3
21 11.5  30052.6
22  1.3  30124.4
23 11.5  60455.6
24  4.3  66048.2
25 21.1  46704.8
26 17.3  47285.4
27  1.4  96509.4
28  0.8 167738.6
29  0.8 113709.1
30  0.0 222321.7
31 10.8  98998.6
32  8.0  65551.2
33  8.0  65955.2
34  5.7  64407.0
35  8.0  66889.1
```

```
36  0.0 140172.5
37 13.0  98998.6
38  6.5  65551.2
39  6.5  65955.2
40  5.7  64407.0
41  6.5  66889.1
42  2.2 140172.5
43 22.7 439162.3
44 17.5  82124.0
45 21.0  88696.0
46  7.5  80698.6
47 17.5  82124.0
48 15.1  61704.3
49 15.1  52238.4
50 10.8  58940.0
51 15.1  46810.7
52  0.0  80582.6
53 21.1  46704.8
54 17.3  53088.6
55 17.3  47285.4
56 14.3  80932.0
57 17.3 117562.3
58 11.5  96770.6
59 16.4 103292.9
60 14.8 120297.7
> var(time)
[1] 50.70457
> var(meanSize)
[1] 4235180915
> var(time,meanSize)
[1] 3592.237
> cor(time,meanSize)
[1] 0.00775185
```

2.2 T-tests for comparative analysis

2.2 T-tests for comparative analysis

Case study 1 results

Critical T for all of the following as all samples = 100

```
> qt(0.975,198)
1.972017
```

Sample e has 98 therefore when paired with a full sample

```
> qt(0.975,196)
1.972141
```

Sample f has 58 therefore when paired with a full sample

```
> qt(0.975,156)
1.975288
```

When e and f are together

```
> qt(0.975,154)
[1] 1.975488
```

Hennigian and evolutionary lineages

> t.test(cs1a,cs1b)

Welch Two Sample t-test

data: cs1a and cs1b **reject null later pop is bigger**
t = -4.0568, df = 136.212, p-value = 8.337e-05
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
-52336.35 -18033.55
sample estimates:
mean of x mean of y
112784.0 147969.0

> t.test(cs1c,cs1d)

Welch Two Sample t-test

data: cs1c and cs1d **null pops are the same**
t = -1.0959, df = 174.239, p-value = 0.2746
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
-27985.491 8002.875
sample estimates:
mean of x mean of y
146635.7 156627.0

> t.test(TAcs1e,TAcs1f)

Welch Two Sample t-test

data: TAcs1e and TAcs1f **reject null later pop is bigger**
t = -3.9397, df = 73.048, p-value = 0.0001848
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
-54596.05 -17914.72
sample estimates:
mean of x mean of y
88179.6 124435.0

> t.test(cs1a,cs1d)

Welch Two Sample t-test

data: cs1a and cs1d **reject null later pop is bigger**
t = -5.2709, df = 139.824, p-value = 5.032e-07
alternative hypothesis: true difference in means is not equal to 0

95 percent confidence interval:
 -60288.18 -27397.72
sample estimates:
mean of x mean of y
 112784.0 156627.0

Either side of cladogenesis
> t.test(cs1a,cs1c)

Welch Two Sample t-test

data: cs1a and cs1c **reject null later pop is bigger**
t = -5.4562, df = 175.063, p-value = 1.641e-07
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -46096.41 -21606.87
sample estimates:
mean of x mean of y
 112784.0 146635.7

> t.test(cs1a,cs1e)

Welch Two Sample t-test

data: cs1a and cs1e **null later pop is smaller**
t = 5.1783, df = 194.825, p-value = 5.558e-07
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 15233.61 33975.25
sample estimates:
mean of x mean of y
 112784.0   88179.6

> t.test(cs1a,cs1d)

Welch Two Sample t-test

data: cs1a and cs1d **reject null later pop is bigger**
t = -5.2709, df = 139.824, p-value = 5.032e-07
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -60288.18 -27397.72
sample estimates:
mean of x mean of y
 112784.0 156627.0

> t.test(cs1a,cs1f)

Welch Two Sample t-test

data: cs1a and cs1f **null pops are the same**
t = -1.2515, df = 76.176, p-value = 0.2146
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -30192.344   6890.439
sample estimates:
mean of x mean of y
 112784.0 124435.0

> t.test(cs1b,cs1c)

Welch Two Sample t-test

data: cs1b and cs1c **null pops are the same**
t = 0.1412, df = 169.271, p-value = 0.8879
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -17306.46 19973.07
sample estimates:
mean of x mean of y
 147969.0 146635.7

> t.test(cs1b,cs1e)

Welch Two Sample t-test

data: cs1b and cs1e **null later pop is smaller**
t = 6.9864, df = 130.474, p-value = 1.299e-10
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 42858.96 76719.81
sample estimates:
mean of x mean of y
 147969.0   88179.6

> t.test(cs1b,cs1d)

Welch Two Sample t-test

data: cs1b and cs1d **null pops are the same**
t = -0.7909, df = 197.499, p-value = 0.43
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -30247.38 12931.38
sample estimates:
mean of x mean of y
 147969.0 156627.0

> t.test(cs1b,cs1f)

Welch Two Sample t-test

data: cs1b and cs1f **null later pop is smaller**
t = 2.0082, df = 137.561, p-value = 0.04658
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
   361.2285 46706.7623
sample estimates:
mean of x mean of y
 147969.0 124435.0

Cladogenetic effects between lineages

> t.test(cs1c,TAcs1e)

Welch Two Sample t-test

data: cs1c and TAcs1e **null later pop is smaller**
t = 9.6745, df = 165.92, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 46526.40 70385.75
sample estimates:
mean of x mean of y
 146635.7   88179.6

> t.test(cs1d,TAcs1f)

Welch Two Sample t-test

data: cs1d and TAcs1f **null later pop is smaller**
t = 2.8094, df = 132.814, p-value = 0.005714
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
  9526.883 54857.108
sample estimates:
mean of x mean of y
 156627.0 124435.0

Case study 2 results

Critical T for all of the following as all samples = 100
> qt(0.975,198)
1.972017

Hennigian and evolutionary lineages

> t.test(cs2a,cs2b)

Welch Two Sample t-test

data: cs2a and cs2b **null later pop smaller**
t = 1.0263, df = 185.989, p-value = 0.3061
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -3060.075 9696.459
sample estimates:
mean of x mean of y
 75334.49 72016.30

> t.test(cs2c,cs2d)

Welch Two Sample t-test

data: cs2c and cs2d **reject null later pop bigger**
t = -7.8058, df = 138.526, p-value = 1.305e-12
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -125263.7 -74630.0
sample estimates:
mean of x mean of y
 147773.9 247720.7

>t.test(cs2e,cf2f)
Welch Two Sample t-test

data: cs2e and cs2f **null pops the same size**
t = -0.6302, df = 183.214, p-value = 0.5293
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -7145.914 3685.900
sample estimates:
mean of x mean of y
 75375.87 77105.87

> t.test(cs2a,cs2d)

Welch Two Sample t-test

data: cs2a and cs2d **reject null later pop bigger**
t = -14.591, df = 104.684, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -195813.0 -148959.3
sample estimates:
mean of x mean of y
 75334.49 247720.69

Either side of cladogenesis
> t.test(cs2a,cs2c)

```
        Welch Two Sample t-test

data:  cs2a and cs2c reject null later pop bigger
t = -12.7738, df = 125.802, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -83662.19 -61216.54
sample estimates:
mean of x mean of y
 75334.49 147773.86

> t.test(cs2a,cs2e)

        Welch Two Sample t-test

data:  cs2a and cs2e null pops the same size
t = -0.014, df = 195.736, p-value = 0.9888
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -5870.484  5787.738
sample estimates:
mean of x mean of y
 75334.49  75375.87

> t.test(cs2a,cs2d)

        Welch Two Sample t-test

data:  cs2a and cs2d reject null later pop bigger
t = -14.591, df = 104.684, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -195813.0 -148959.3
sample estimates:
mean of x mean of y
 75334.49 247720.69

> t.test(cs2a,cs2f)

        Welch Two Sample t-test

data:  cs2a and cs2f null pops the same size
t = -0.6897, df = 191.645, p-value = 0.4912
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -6836.923  3294.163
sample estimates:
mean of x mean of y
 75334.49  77105.87
```

```
> t.test(cs2b,cs2c)

        Welch Two Sample t-test

data:  cs2b and cs2c reject null later pop bigger
t = -12.8392, df = 142.578, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -87421.34 -64093.77
sample estimates:
mean of x mean of y
  72016.3  147773.9

> t.test(cs2b,cs2e)

        Welch Two Sample t-test

data:  cs2b and cs2e null about the same size
t = -0.9953, df = 193.604, p-value = 0.3208
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -10016.595   3297.465
sample estimates:
mean of x mean of y
 72016.30  75375.87

> t.test(cs2b,cs2d)

        Welch Two Sample t-test

data:  cs2b and cs2d reject null later pop bigger
t = -14.7324, df = 108.543, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -199343.3 -152065.5
sample estimates:
mean of x mean of y
  72016.3  247720.7

> t.test(cs2b,cs2f)

        Welch Two Sample t-test

data:  cs2b and cs2f null about the same size
t = -1.6733, df = 168.679, p-value = 0.09613
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -11094.2587    915.1147
sample estimates:
mean of x mean of y
```

72016.30 77105.87

Cladogenetic effects between lineages

> t.test(cs2c,cs2e)

Welch Two Sample t-test

data: cs2c and cs2e **null later pop smaller**
t = 12.584, df = 131.929, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
61017.55 83778.44
sample estimates:
mean of x mean of y
147773.86 75375.87

> t.test(cs2d,cs2f)

Welch Two Sample t-test

data: cs2d and cs2f **null later pop smaller**
t = 14.5036, df = 102.934, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
147284.3 193945.3
sample estimates:
mean of x mean of y
247720.69 77105.87

Case study 3 results

Critical T for all samples = 100
> qt(0.975,198)
1.972017
cs3f = 71 therefore
> qt(0.975,169)
1.974100

Anagenetic change

> t.test(cs3a,cs3b)

Welch Two Sample t-test

data: cs3a and cs3b **null later pop smaller**
t = 19.5522, df = 108.704, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
45478.01 55738.45
sample estimates:

mean of x mean of y
 74877.19 24268.96

> t.test(cs3c,cs3d)

        Welch Two Sample t-test

data: cs3c and cs3d **null later pop smaller**
t = 2.9838, df = 184.555, p-value = 0.003232
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
  909.8525 4461.2495
sample estimates:
mean of x mean of y
 24631.86 21946.31

> t.test(cs3e,cs3f)

        Welch Two Sample t-test

data: cs3e and cs3f **reject null later pop bigger**
t = -4.2387, df = 143.617, p-value = 4.002e-05
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -7611.358 -2770.198
sample estimates:
mean of x mean of y
 28486.87 33677.64

> t.test(cs3a,cs3d)

        Welch Two Sample t-test

data: cs3a and cs3d **null later pop smaller**
t = 20.4771, df = 108.149, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 47807.27 58054.50
sample estimates:
mean of x mean of y
 74877.19 21946.31

Either side of cladogenesis
> t.test(cs3a,cs3c)

        Welch Two Sample t-test

data: cs3a and cs3c **null later pop smaller**
t = 19.1277, df = 114.845, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0

95 percent confidence interval:
 45042.00 55448.67
sample estimates:
mean of x mean of y
 74877.19 24631.86

> t.test(cs3a,cs3e)

        Welch Two Sample t-test

data: cs3a and cs3e **null later pop smaller**
t = 17.592, df = 116.471, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 41167.61 51613.05
sample estimates:
mean of x mean of y
 74877.19 28486.87

> t.test(cs3a,cs3d)

        Welch Two Sample t-test

data: cs3a and cs3d **null later pop smaller**
t = 20.4771, df = 108.149, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 47807.27 58054.50
sample estimates:
mean of x mean of y
 74877.19 21946.31

> t.test(cs3a,cs3f)

        Welch Two Sample t-test

data: cs3a and cs3f **null later pop smaller**
t = 15.2303, df = 126.197, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 35846.29 46552.81
sample estimates:
mean of x mean of y
 74877.19 33677.64

> t.test(cs3b,cs3c)

        Welch Two Sample t-test

data: cs3b and cs3c **null pops the same size**

t = -0.3988, df = 187.022, p-value = 0.6905
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -2158.081 1432.289
sample estimates:
mean of x mean of y
 24268.96 24631.86

> t.test(cs3b,cs3e)

Welch Two Sample t-test

data: cs3b and cs3e **reject null later pop bigger**
t = -4.492, df = 182.804, p-value = 1.248e-05
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -6070.528 -2365.278
sample estimates:
mean of x mean of y
 24268.96 28486.87

> t.test(cs3b,cs3d)

Welch Two Sample t-test

data: cs3b and cs3d **null later pop smaller**
t = 2.9752, df = 197.827, p-value = 0.003293
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
  783.1442 3862.1658
sample estimates:
mean of x mean of y
 24268.96 21946.31

> t.test(cs3b,cs3f)

Welch Two Sample t-test

data: cs3b and cs3f **reject null later pop bigger**
t = -8.4307, df = 115.795, p-value = 1.094e-13
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -11619.10 -7198.26
sample estimates:
mean of x mean of y
 24268.96 33677.64

Cladogenetic effects between lineages
> t.test(cs3c,cs3e)

Welch Two Sample t-test

data: cs3c and cs3e **reject null later pop bigger**
t = -3.7055, df = 197.516, p-value = 0.0002738
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -5906.604 -1803.410
sample estimates:
mean of x mean of y
 24631.86 28486.87

> t.test(cs3d,cs3f)

Welch Two Sample t-test

data: cs3d and cs3f **reject null later pop bigger**
t = -10.5888, df = 113.408, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -13926.193 -9536.479
sample estimates:
mean of x mean of y
 21946.31 33677.64

Case study 4 results

Critical T for all samples = 100
> qt(0.975,198)
1.972017

Hennigian and evolutionary lineages

> t.test(cs4a,cs4b)

Welch Two Sample t-test

data: cs4a and cs4b **reject null later pop is bigger**
t = -24.6448, df = 139.815, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -28271.65 -24072.46
sample estimates:
mean of x mean of y
 19606.26 45778.32

> t.test(cs4c,cs4d)

Welch Two Sample t-test

data: cs4c and cs4d **null pops are same size**
t = -0.083, df = 185.321, p-value = 0.9339

alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -1777.982 1634.346
sample estimates:
mean of x mean of y
 30052.61 30124.42

> t.test(cs4e,cs4f)

Welch Two Sample t-test

data: cs4e and cs4f **reject null later pop is bigger**
t = -1.9935, df = 197.826, p-value = 0.04758
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -11124.86342   -60.23458
sample estimates:
mean of x mean of y
 60455.61 66048.16

> t.test(cs4a,cs4d)

Welch Two Sample t-test

data: cs4a and cs4d **reject null later pop is bigger**
t = -15.241, df = 193.08, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -11879.310 -9157.022
sample estimates:
mean of x mean of y
 19606.26 30124.42

Either side of cladogenesis
> t.test(cs4a,cs4c)

Welch Two Sample t-test

data: cs4a and cs4c **reject null later pop is bigger**
t = -12.7442, df = 170.182, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -12064.423 -8828.273
sample estimates:
mean of x mean of y
 19606.26 30052.61

> t.test(cs4a,cs4e)

Welch Two Sample t-test

data: cs4a and cs4e **reject null later pop is bigger**
t = -20.3778, df = 109.349, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -44822.26 -36876.45
sample estimates:
mean of x mean of y
 19606.26 60455.61

> t.test(cs4a,cs4d)

        Welch Two Sample t-test

data: cs4a and cs4d **reject null later pop is bigger**
t = -15.241, df = 193.08, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -11879.310 -9157.022
sample estimates:
mean of x mean of y
 19606.26 30124.42

> t.test(cs4a,cs4f)

        Welch Two Sample t-test

data: cs4a and cs4f **reject null later pop is bigger**
t = -22.5222, df = 108.755, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -50528.93 -42354.88
sample estimates:
mean of x mean of y
 19606.26 66048.16

> t.test(cs4b,cs4c)

        Welch Two Sample t-test

data: cs4b and cs4c **null later pop smaller**
t = 13.2933, df = 179.004, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 13391.34 18060.08
sample estimates:
mean of x mean of y
 45778.32 30052.61

> t.test(cs4b,cs4e)

Welch Two Sample t-test

data: cs4b and cs4e **reject null later pop is bigger**
t = -6.7373, df = 144.423, p-value = 3.566e-10
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
-18983.20 -10371.40
sample estimates:
mean of x mean of y
45778.32 60455.61

> t.test(cs4b,cs4d)

Welch Two Sample t-test

data: cs4b and cs4d **null later pop smaller**
t = 14.2674, df = 153.143, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
13486.33 17821.45
sample estimates:
mean of x mean of y
45778.32 30124.42

> t.test(cs4b,cs4f)

Welch Two Sample t-test

data: cs4b and cs4f **reject null later pop is bigger**
t = -9.0835, df = 142.073, p-value = 8.14e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
-24681.08 -15858.61
sample estimates:
mean of x mean of y
45778.32 66048.16

Cladogenetic effects between lineages
> t.test(cs4c,cs4e)

Welch Two Sample t-test

data: cs4c and cs4e **reject null descendant is bigger than ancestor**
t = -14.6786, df = 123.096, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
-34502.89 -26303.13
sample estimates:
mean of x mean of y

30052.61 60455.61

> t.test(cs4d,cs4f)

Welch Two Sample t-test

data: cs4d and cs4f **reject null descendant is bigger than ancestor**
t = -17.2677, df = 112.432, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -40045.62 -31801.86
sample estimates:
mean of x mean of y
 30124.42 66048.16

Case study 5 results

Critical T for all samples = 100
> qt(0.975,198)
1.972017

Hennigian and evolutionary lineages

>t.test(cs5c,cs5d)

Welch Two Sample t-test

data: cs5c and cs5d **null pops same size**
t = -0.3784, df = 191.807, p-value = 0.7055
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -3606.696 2445.506
sample estimates:
mean of x mean of y
 46704.82 47285.42

Either side of cladogenesis

No data available

Cladogenetic effects between lineages

No data available

Case study 6 results

Critical T for all samples = 100
> qt(0.975,198)
1.972017

Hennigian and evolutionary lineages

> t.test(cs6a,cs6b)

Welch Two Sample t-test

data: cs6a and cs6b **reject null later pop bigger**
t = -15.3457, df = 167.805, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -80392.73 -62065.70
sample estimates:
mean of x mean of y
 96509.43 167738.65

> t.test(cs6c,cs6d)

Welch Two Sample t-test

data: cs6c and cs6d **reject null later pop bigger**
t = -17.5006, df = 152.987, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -120873.54 -96351.57
sample estimates:
mean of x mean of y
 113709.1 222321.7

> t.test(cs6a,cs6d)

Welch Two Sample t-test

data: cs6a and cs6d **reject null later pop bigger**
t = -20.9956, df = 138.618, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -137660.4 -113964.1
sample estimates:
mean of x mean of y
 96509.43 222321.68

Either side of cladogenesis
> t.test(cs6a,cs6c) **reject null later pop bigger**

Welch Two Sample t-test

data: cs6a and cs6c
t = -4.4387, df = 192.195, p-value = 1.523e-05
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -24842.54 -9556.87
sample estimates:
mean of x mean of y

96509.43 113709.13

> t.test(cs6a,cs6d)

Welch Two Sample t-test

data: cs6a and cs6d **reject null later pop is bigger**
t = -20.9956, df = 138.618, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
-137660.4 -113964.1
sample estimates:
mean of x mean of y
96509.43 222321.68

> t.test(cs6b,cs6c)

Welch Two Sample t-test

data: cs6b and cs6c **null decendant is smaller**
t = 10.9935, df = 184.515, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
44333.31 63725.71
sample estimates:
mean of x mean of y
167738.6 113709.1

> t.test(cs6b,cs6d)

Welch Two Sample t-test

data: cs6b and cs6d **reject null later pop is bigger**
t = -8.1325, df = 179.728, p-value = 6.668e-14
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
-67826.93 -41339.15
sample estimates:
mean of x mean of y
167738.6 222321.7

Cladogenetic effects between lineages
No data available

Case study 7 results
Critical T for all samples = 100
> qt(0.975,198)
1.972017

Sample cs7d = 59 therefore
> qt(0.975,157)
1.975189

Anagentic change
> t.test(cs7a,cs7b)

Welch Two Sample t-test

data: cs7a and cs7b **null later pop is smaller**
t = 10.5541, df = 154.841, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
27187.05 39707.68
sample estimates:
mean of x mean of y
98998.58 65551.21

> t.test(cs7c,cs7d)

Welch Two Sample t-test

data: cs7c and cs7d **null pops approx the same**
t = 0.6862, df = 119.276, p-value = 0.4939
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
-2919.223 6015.669
sample estimates:
mean of x mean of y
65955.20 64406.98

> t.test(cs7e,cs7f)

Welch Two Sample t-test

data: cs7e and cs7f **reject null later pop is bigger**
t = -15.1615, df = 116.396, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
-82856.45 -63710.35
sample estimates:
mean of x mean of y
66889.14 140172.54

> t.test(cs7a,cs7d)

Welch Two Sample t-test

data: cs7a and cs7d **null later pop is smaller**
t = 10.4606, df = 153.666, p-value < 2.2e-16

alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 28058.85 41124.36
sample estimates:
mean of x mean of y
 98998.58 64406.98

Either side of cladogenesis

> t.test(cs7b,cs7c)

Welch Two Sample t-test

data: cs7b and cs7c **null pops approx the same**
t = -0.1972, df = 194.751, p-value = 0.8439
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -4445.212 3637.240
sample estimates:
mean of x mean of y
 65551.21 65955.20

> t.test(cs7b,cs7e)

Welch Two Sample t-test

data: cs7b and cs7e **null pops approx the same**
t = -0.6474, df = 195.63, p-value = 0.5181
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -5413.645 2737.791
sample estimates:
mean of x mean of y
 65551.21 66889.14

Cladogenetic effects between lineages

> t.test(cs7c,cs7e)

Welch Two Sample t-test

data: cs7c and cs7e **null pops approx the same**
t = -0.4837, df = 197.926, p-value = 0.6292
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -4741.860 2873.978
sample estimates:
mean of x mean of y
 65955.20 66889.14

> t.test(cs7d,cs7f)

Welch Two Sample t-test

data: cs7d and cs7f **reject null later pop is bigger**
t = -15.2372, df = 126.399, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -85605.50 -65925.63
sample estimates:
mean of x mean of y
 64406.98 140172.54

Case study 8 results

Critical T for all samples = 100
> qt(0.975,198)
1.972017
Sample d has 29 therefore when paired with a full sample
> qt(0.975,126)
1.978971
Sample f has 10 therefore when paired with a full sample
> qt(0.975,109)
1.981967
When d and f are together
> qt(0.975,37)
[1] 2.026192

Hennigian and evolutionary lineages

> t.test(cs8a,cs8b)

Welch Two Sample t-test

data: cs8a and cs8b **null pops approx same size**
t = 0.0847, df = 161.695, p-value = 0.9326
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -37263.10 40603.87
sample estimates:
mean of x mean of y
 439162.3 437491.9

> t.test(cs8c,cs8d)

Welch Two Sample t-test

data: cs8c and cs8d **null later pop is smaller**
t = 5.3384, df = 45.313, p-value = 2.907e-06
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:

 65107.0 143975.2
sample estimates:
mean of x mean of y
 457033.4 352492.3

> t.test(cs8e,cs8f)

 Welch Two Sample t-test

data: cs8e and cs8f **null pops approx the same**
t = 1.0006, df = 10.805, p-value = 0.3389
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -55363.15 147285.91
sample estimates:
mean of x mean of y
 577652.1 531690.7

> t.test(cs8a,cs8d)

 Welch Two Sample t-test

data: cs8a and cs8d **null later pops get smaller**
t = 3.6031, df = 83.904, p-value = 0.0005319
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
  38835.08 134504.96
sample estimates:
mean of x mean of y
 439162.3 352492.3

Either side of cladogenesis
> t.test(cs8a,cs8c)

 Welch Two Sample t-test

data: cs8a and cs8c **null pops approx the same**
t = -0.9195, df = 156.306, p-value = 0.3593
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -56263.37 20521.24
sample estimates:
mean of x mean of y
 439162.3 457033.4

> t.test(cs8a,cs8e)

 Welch Two Sample t-test

data: cs8a and cs8e **reject null later pop bigger**

```
t = -6.3777, df = 189.253, p-value = 1.344e-09
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -181323.59  -95656.03
sample estimates:
mean of x mean of y
 439162.3  577652.1

> t.test(cs8a,cs8d)

        Welch Two Sample t-test
```

data: cs8a and cs8d **null later pop smaller**

```
t = 3.6031, df = 83.904, p-value = 0.0005319
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
  38835.08 134504.96
sample estimates:
mean of x mean of y
 439162.3  352492.3

> t.test(cs8a,cs8f)

        Welch Two Sample t-test
```

data: cs8a and cs8f **null pops approx the same**

```
t = -1.9676, df = 11.854, p-value = 0.07295
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -195127.26   10070.40
sample estimates:
mean of x mean of y
 439162.3  531690.7

> t.test(cs8b,cs8c)

        Welch Two Sample t-test
```

data: cs8b and cs8c **null pops approx same size**

```
t = -1.4045, df = 197.371, p-value = 0.1618
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -46980.243   7897.343
sample estimates:
mean of x mean of y
 437491.9  457033.4

> t.test(cs8b,cs8e)

        Welch Two Sample t-test
```

data: cs8b and cs8e **reject null later pop is bigger**
t = -8.2685, df = 182.814, p-value = 2.719e-14
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -173605.0 -106715.4
sample estimates:
mean of x mean of y
 437491.9 577652.1

```
> t.test(cs8b,cs8d)
```

Welch Two Sample t-test

data: cs8b and cs8d **null later pop smaller**
t = 4.28, df = 47.618, p-value = 8.974e-05
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
  45060.65 124938.62
sample estimates:
mean of x mean of y
 437491.9 352492.3

```
> t.test(cs8b,cs8f)
```

Welch Two Sample t-test

data: cs8b and cs8f **reject null later pop is bigger**
t = -2.0922, df = 9.979, p-value = 0.06295
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -194547.170   6149.534
sample estimates:
mean of x mean of y
 437491.9 531690.7

Cladogenetic effects between lineages

```
> t.test(cs8c,cs8e)
```

Welch Two Sample t-test

data: cs8c and cs8e **reject null later pop is bigger**
t = -7.255, df = 177.575, p-value = 1.200e-11
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -153427.83 -87809.66
sample estimates:
mean of x mean of y
 457033.4 577652.1

> t.test(cs8d,cs8f)

Welch Two Sample t-test

data: cs8d and cs8f **reject null later pop is bigger**
t = -3.8058, df = 11.848, p-value = 0.002559
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -281935.09 -76461.82
sample estimates:
mean of x mean of y
 352492.3 531690.7

Case study 9 results

Critical T for all of the following as all samples = 100
> qt(0.975,198)
1.972017

Hennigian and evolutionary lineages

> t.test(cs9c,cs9d)

Welch Two Sample t-test

data: cs9c and cs9d **null later pop is smaller**
t = 13.5186, df = 197.008, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 53321.30 71535.26
sample estimates:
mean of x mean of y
144552.32 82124.04

> t.test(cs9e,cs9f)

Welch Two Sample t-test

data: cs9e and cs9f **null later pop is smaller**
t = 2.2357, df = 166.613, p-value = 0.0267
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
   935.1602 15059.7342
sample estimates:
mean of x mean of y
 88696.01 80698.56

Either side of cladogenesis

No ancestor data

Cladogenetic effects between lineages

```
> t.test(cs9c,cs9e)

        Welch Two Sample t-test
```

data: cs9c and cs9e **null later pop is smaller**
t = 12.7871, df = 197.709, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 47242.10 64470.51
sample estimates:
mean of x mean of y
144552.32 88696.01

```
> t.test(cs9d,cs9f)

        Welch Two Sample t-test
```

data: cs9d and cs9f **null pops are not different**
t = 0.3676, df = 156.048, p-value = 0.7137
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -6235.015 9085.956
sample estimates:
mean of x mean of y
 82124.04 80698.56

Case study 10 results

Critical T for all samples = 100
> qt(0.975,198)
1.972017

Hennigian and evolutionary lineages

```
> t.test(cs10a,cs10b)

        Welch Two Sample t-test
```

data: cs10a and cs10b **null later pop gets smaller**
t = 5.5922, df = 131.281, p-value = 1.248e-07
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 13196.36 27643.05
sample estimates:
mean of x mean of y
 82124.04 61704.33

```
> t.test(cs10c,cs10d)

        Welch Two Sample t-test
```

data: cs10c and cs10d **reject null later pop gets bigger**
t = -3.4413, df = 193.351, p-value = 0.0007094
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -10542.488 -2860.702
sample estimates:
mean of x mean of y
 52238.36 58939.96

> t.test(cs10e,cs10f)

    Welch Two Sample t-test

data: cs10e and cs10f **reject null later pop gets bigger**
t = -9.8437, df = 140.583, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -40554.45 -26989.20
sample estimates:
mean of x mean of y
 46810.74 80582.56

> t.test(cs10a,cs10d)

    Welch Two Sample t-test

data: cs10a and cs10d **null later pop gets smaller**
t = 6.2845, df = 135.629, p-value = 4.181e-09
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 15888.48 30479.68
sample estimates:
mean of x mean of y
 82124.04 58939.96

Either side of cladogenesis
> t.test(cs10a,cs10c)

    Welch Two Sample t-test

data: cs10a and cs10c **null later pop smaller**
t = 8.282, df = 126.244, p-value = 1.498e-13
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 22744.65 37026.70
sample estimates:
mean of x mean of y
 82124.04 52238.36

> t.test(cs10a,cs10e)

Welch Two Sample t-test

data: cs10a and cs10e **null later pop smaller**
t = 9.5957, df = 134.599, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 28034.94 42591.66
sample estimates:
mean of x mean of y
 82124.04 46810.74

> t.test(cs10a,cs10d)

Welch Two Sample t-test

data: cs10a and cs10d **null later pop smaller**
t = 6.2845, df = 135.629, p-value = 4.181e-09
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 15888.48 30479.68
sample estimates:
mean of x mean of y
 82124.04 58939.96

> t.test(cs10a,cs10f)

Welch Two Sample t-test

data: cs10a and cs10f **null pops same size**
t = 0.3359, df = 196.607, p-value = 0.7373
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -7509.92 10592.87
sample estimates:
mean of x mean of y
 82124.04 80582.56

> t.test(cs10b,cs10c)

Welch Two Sample t-test

data: cs10b and cs10c **null later pop smaller**
t = 5.0481, df = 196.455, p-value = 1.014e-06
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
  5767.957 13163.984
sample estimates:
mean of x mean of y

 61704.33 52238.36

> t.test(cs10b,cs10e)

        Welch Two Sample t-test

data: cs10b and cs10e **null later pop smaller**
t = 7.4116, df = 197.465, p-value = 3.574e-12
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 10930.74 18856.45
sample estimates:
mean of x mean of y
 61704.33 46810.74

> t.test(cs10b,cs10d)

        Welch Two Sample t-test

data: cs10b and cs10d **null pops same size**
t = 1.3645, df = 197.107, p-value = 0.1740
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -1230.828 6759.579
sample estimates:
mean of x mean of y
 61704.33 58939.96

> t.test(cs10b,cs10f)

        Welch Two Sample t-test

data: cs10b and cs10f **reject null later pop bigger**
t = -5.5524, df = 136.799, p-value = 1.415e-07
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -25601.66 -12154.80
sample estimates:
mean of x mean of y
 61704.33 80582.56

Cladogenetic effects between lineages
> t.test(cs10c,cs10e)

        Welch Two Sample t-test

data: cs10c and cs10e **null later pop gets smaller**
t = 2.8117, df = 194.19, p-value = 0.005434
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:

1620.458 9234.792
sample estimates:
mean of x mean of y
52238.36 46810.74

> t.test(cs10d,cs10f)

Welch Two Sample t-test

data: cs10d and cs10f **reject null later pop gets bigger**
t = -6.2907, df = 141.753, p-value = 3.690e-09
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
-28443.76 -14841.45
sample estimates:
mean of x mean of y
58939.96 80582.56

Case study 11 results

Critical T for all samples = 100
> qt(0.975,198)
1.972017

Hennigian and evolutionary lineages

> t.test(cs11a,cs11b)

Welch Two Sample t-test

data: cs11a and cs11b **reject null later pop is bigger**
t = -4.0654, df = 194.897, p-value = 6.952e-05
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
-9480.582 -3286.887
sample estimates:
mean of x mean of y
46704.82 53088.56

> t.test(cs11c,cs11d)

Welch Two Sample t-test

data: cs11c and cs11d **reject null later pop is bigger**
t = -12.9925, df = 131.381, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
-38769.44 -28523.69
sample estimates:
mean of x mean of y
47285.42 80931.98

> t.test(cs11e,cs11f)

Welch Two Sample t-test

data: cs11e and cs11f **null later pop is smaller**
t = 6.0553, df = 196.241, p-value = 7.011e-09
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 13703.33 26940.38
sample estimates:
mean of x mean of y
117092.47 96770.61

> t.test(cs11a,cs11d)

Welch Two Sample t-test

data: cs11a and cs11d **reject null later pop is bigger**
t = -12.8187, df = 144.238, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -39504.74 -28949.59
sample estimates:
mean of x mean of y
 46704.82 80931.98

Either side of cladogenesis
> t.test(cs11a,cs11c)

Welch Two Sample t-test

data: cs11a and cs11c **null pops same size**
t = -0.3784, df = 191.807, p-value = 0.7055
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -3606.700 2445.504
sample estimates:
mean of x mean of y
 46704.82 47285.42

> t.test(cs11a,cs11e)

Welch Two Sample t-test

data: cs11a and cs11e **reject null later pop bigger**
t = -25.6115, df = 141.44, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -75820.67 -64954.62

sample estimates:
mean of x mean of y
 46704.82 117092.47

> t.test(cs11a,cs11d)

Welch Two Sample t-test

data: cs11a and cs11d **reject null later pop bigger**
t = -12.8187, df = 144.238, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -39504.74 -28949.59
sample estimates:
mean of x mean of y
 46704.82 80931.98

> t.test(cs11a,cs11f)

Welch Two Sample t-test

data: cs11a and cs11f **reject null later pop bigger**
t = -19.6576, df = 149.197, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -55098.44 -45033.14
sample estimates:
mean of x mean of y
 46704.82 96770.61

> t.test(cs11b,cs11c)

Welch Two Sample t-test

data: cs11b and cs11c **null later pop is smaller**
t = 4.0603, df = 197.408, p-value = 7.062e-05
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 2984.612 8621.661
sample estimates:
mean of x mean of y
 53088.56 47285.42

> t.test(cs11b,cs11e)

Welch Two Sample t-test

data: cs11b and cs11e **reject null later pop is bigger**
t = -23.7837, df = 132.575, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0

95 percent confidence interval:
 -69326.93 -58680.89
sample estimates:
mean of x mean of y
 53088.56 117092.47

> t.test(cs11b,cs11d)

Welch Two Sample t-test

data: cs11b and cs11d **reject null later pop bigger**
t = -10.6631, df = 134.89, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -33007.59 -22679.26
sample estimates:
mean of x mean of y
 53088.56 80931.98

> t.test(cs11b,cs11f)

Welch Two Sample t-test

data: cs11b and cs11f **reject null later pop bigger**
t = -17.5778, df = 139.049, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -48595.46 -38768.65
sample estimates:
mean of x mean of y
 53088.56 96770.61

Cladogenetic effects between lineages
> t.test(cs11c,cs11e)

Welch Two Sample t-test

data: cs11c and cs11e **reject null later pop is bigger**
t = -26.1427, df = 129.266, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -75090.05 -64524.04
sample estimates:
mean of x mean of y
 47285.42 117092.47

> t.test(cs11d,cs11f)

Welch Two Sample t-test

data: cs11d and cs11f **reject null later pop is bigger**
t = -4.8108, df = 197.306, p-value = 2.981e-06
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -22331.270 -9345.987
sample estimates:
mean of x mean of y
 80931.98 96770.61

2.3 Pearson's Chi-squared test of size increase v's decrease proportion data

Ancestor-descendant relationship	Increase in mean area	No increase in mean area
Hennigian lineage	14	15
Evolutionary Lineage	11	10
Ancestor-decendant after cladogenesis	10	8
Early ancestor population with all after cladogenesis populations	15	19
Later ancestor population with all after cladogenesis populations	14	20

```
> chisqd<-matrix(c(14,15,11,10,10,8,15,19,14,20),ncol=2)
> chisqd
     [,1] [,2]
[1,]   14    8
[2,]   15   15
[3,]   11   19
[4,]   10   14
[5,]   10   20
> chisq.test(chisqd,correct=F)

        Pearson's Chi-squared test

data:  chisqd
X-squared = 5.97, df = 4, p-value = 0.2014

> qchisq(0.95,4)
```

[1] 9.487729 **we do not exceed the critical value, therefore we can't reject the null hypothesis that change in mean area is independent of what your ancestor-descendant evolutionary relationship is**.

Appendix 3. Aze *et al.*, (2011) and Ezard *et al.*, (2011). Papers attached at the end of the appendices.

Summary of additional analysis included in "A phylogeny of Cenozoic macroperforate planktonic foraminifera from fossil data"

The following section includes further analyses of the phylogenies presented in Chapter 2. Although this work was included in the manuscript "A phylogeny of Cenozoic macroperforate planktonic foraminifera from fossil data" (Aze *et al.*, 2011) it was excluded from Chapter 2 as it was conducted by my co-author Professor Andy Purvis and is not my own work. The findings of these analyses are nonetheless important and are therefore summarised below.

3.3.1 Assessment of the completeness of the fossil record

To determine the accuracy of the stratigraphic ranges of the morphospecies included in the phylogenies, data downloaded from the NEPTUNE database (Lazarus, 1994; Spencer-Cervato, 1999) was used to generate a minimum estimate of the completeness of the record for Cenozoic macroperforate planktonic foraminifera. The data from NEPTUNE represents 165 holes drilled by the DSDP and ODP but has some limitations and stratigraphic ranges can be under-represented for three reasons; they might have a very incomplete fossil record; they might have a complete record but the data are from cores not in NEPTUNE; or they might be underrepresented in NEPTUNE because of taxonomic changes.

85,742 occurrence records from NEPTUNE (downloaded on 16 August 2009) were matched to the 340 morphospecies in the phylogeny; only 51 have no occurrence records in the database. Of the 51 morphospecies not included nearly all are absent for the following reasons; Paleocene and Eocene forms have recently been reviewed by the Paleocene Working Group (Olsson *et al.*, 1999; Pearson *et al.*, 2006) and the resulting taxonomic changes and newly described species are too recent to be included in the database. Others are rare excursion taxa which although uncommon in the fossil record have been found to be valid species.

For the 289 morphospecies that had records the proportion of its duration (according to the phylogeny) that is represented in the database was calculated, as proportion of time bins containing at least one recorded occurrence. At a bin length of 1 million years, 173 species (60%) have complete fossil records, i.e. every bin contains a record. Across the 289 species, median completeness is 100% and the mean completeness is 83.4%. Even at a bin length of 0.5 million years, 126 species (44%) have complete records; median completeness is 91.7% and mean completeness 77.2%. These figures, considering the limitations of NEPTUNE, suggest that the species-level fossil record of Cenozoic macroperforate planktonic foraminifera is equivalent to, if not better than, the genus-level records of the best-preserved macroinvertebrate groups (quantified by Foote & Sepkoski, 1999).

3.3.2 Comparison with molecular phylogenies

SSU rDNA is the only planktonic foraminiferal gene to have been extensively sequenced to date. Alignment of this gene is complicated because of extreme rate heterogeneity among lineages and variable length ‘expansion sequences’. As a result most studies have only analysed approximately 600 base pairs from the 3′ end of the gene (Aurahs *et al*., 2009). Darling *et al*.’s (1997) neighbour-joining tree was the first comprehensive attempt to understand phylogenetic affinity based on genes and included eight species. There is agreement with our phylogeny on the relationships between *Globigerinoides ruber, G. conglobatus, G. trilobus, Orbulina universa* and *Globigerinella siphonifera*. However, the molecular phylogenies give support to a close association between *Globigerina* and *Menardella menardii*, and places *Neogloboquadrina dutertrei* within a benthic clade, these relationships conflict with our phylogeny and are taxonomically discrepant. de Vargas *et al*. (1997) produced a phylogeny including the same eight species and four others using maximum parsimony analysis. This approach supported Globorotaliidae and Globigerinidae as clades, in agreement with our phylogeny. Only one of the seven clades analysed in Darling *et al*. (1997) concords with de Vargas *et al*.’s (1997) phylogeny and the authors attributed the differences to rate heterogeneity biasing phylogenetic inferences.

Fourteen of the morphospecies in our phylogeny have been included in the most recent analysis of the group (Aurahs *et al*. 2009). The authors ameliorate alignment difficulties by using eleven different automated alignment algorithms and then analyse each resulting alignment by maximum likelihood. Eight of a possible 13 clades support the relationships in our phylogeny and their tree agrees with ours on a basal split between globigerinids and Globorotaliidae. Agreement is generally good within the globigeriniids, but relationships within Globorotaliidae are less fitting. Aurahs *et al*. (2009) highlight that some probable misidentifications may have hampered earlier analyses.

The presence of cryptic species in the modern oceans has been highlighted by a number of molecular studies. Darling & Wade (2008) report 53 genotypes within 17 macroperforate species. Ujiie & Lipps (2009), using the more stringent methods find 28 distinct genotypes within the 14 macroperforate species in their dataset. It is possible to statistically delimit genetic species based on sequences of a single gene from a geographically wide-ranging sample of individuals. This requires identification of branching tempo changes from population-level coalescence to among-species phylogeny (Pons *et al*., 2006), but this approach has so far not been applied to planktonic foraminifera.

Higher sampling resolution may improve the molecular phylogenetic approach by reducing the length of the longer branches. Additional sequencing (which has begun: Longet & Pawlowski, 2007) could increase resolving power and decrease the issues of rate heterogeneity should different patterns of rates be discovered. Extraction procedures that do not destroy the tests have been devised (Morard *et al*., 2009) which facilitates verification of morphospecies identifications after sequencing. This is particularly important as sequenced specimens that have been collected from the open ocean may not have reached maturity and many species are delimited taxonomically by the chambers that are calcified in the later stages of their ontogenetic development. In spite of the above mentioned advances, a time-table of lineage diversions (Electronic Appendix, Part D) derived from our phylogeny illustrates that robustly resolving basal relationships within the macroperforate clade from sequence data will still be difficult because the early divergences were close together in time (Rokas *et al*., 2005).

3.4 Summary of "Interplay between Changing Climate and Species' Ecology Drives Macroevolutionary Dynamics"

The following section summarises the recent publication *Interplay between changing climate and species' ecology drives macroevolutionary dynamics* (Ezard *et al*., 2011). The paper used a modelling approach to analyse the evolutionary lineage phylogeny presented in Chapter 2 and Aze *et al*. (2011). Note that figures and figure captions have been copied directly from Ezard *et al*. (2011).

It is well known that environmental change influences speciation and extinction, but how biotic and abiotic interactions drive clade dynamics is not well understood. In order to address these concepts, analyses need to be conducted on data where robust information on phylogenetic affinity, range information and species ecology is available. The information presented in Aze *et al*. (2011) met these requirements and consequently the Cenozoic macroperforate planktonic foraminifera provide a model system for disentangling whether biological or environmental influences exert more control on macroevolution.

The “Red Queen” model (Van Valen, 1973) implies that macroevolution is principally driven by species interactions with diversification rate decreasing as a clade nears its carrying capacity. When this capacity is reached an equilibrium state will be maintained with ongoing turnover. If however, environmental change drives the evolution of a group (styled “Court Jester”: Barnosky, 2001) clade-wide effects should be seen in response to abrupt abiotic perturbations; for example, the macroperforate planktonic foraminifera extinction event that was coincident with the abrupt change in global climate and associated development of Antarctic glaciation during the E/O transition.

A discrete time modelling approach was used to predict clade growth and the fit was found to be poor when using only climate as the control (Figure 3.5.A). Models fits were equally poor when clade growth was controlled only by diversity dependence (Figure 3.5.B) illustrating that purely biotic or purely abiotic models cannot predict planktonic foraminiferal macroevolution. Combined information about depth habitat and morphology (taken from Aze *et al*., 2011) was used to define species ecology and controlling for clade growth with ecology resulted in a better prediction than with just climate or diversity dependence, but it was still not a good fit (Figure 3.5.C). When pairs of these factors were permitted to interact in the model there was still only a moderate fit (Figure 3.5.D and E). Strong support from the model was found only when species with distinct ecologies were permitted to respond differently to changing diversity and climate (Figure 3.5.F). These findings suggest that Red Queen and Court Jester are not mutually exclusive, ecological variation allowed clade diversity to respond rapidly to climatic change.

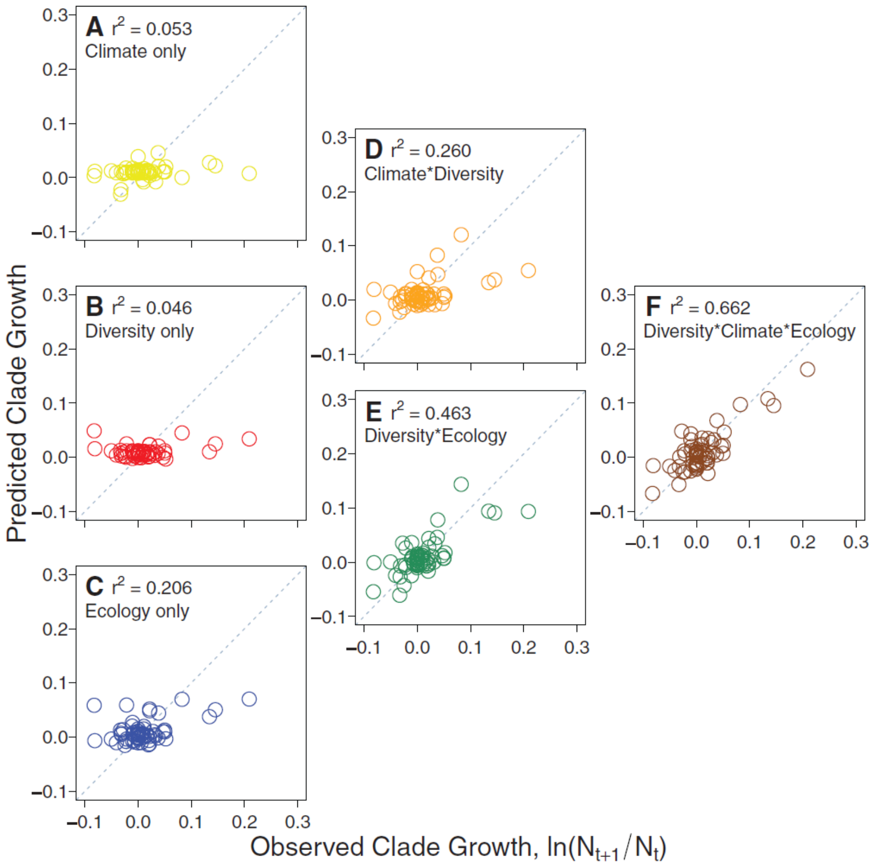

Figure 3.5 Discrete time models incorporating interactions among diversity, climate and species' ecology outperformed all others. The dashed grey line is y=x; a model that predicted observed clade growth perfectly would have points only on this line.

Parametric survival analysis with censoring allowed speciation and extinction as continuous-time processes to eliminate noise that may result from binning the data. This approach allowed direct testing of two venerable macroevolutionary concepts, that a species age does not affect its chance of going extinct (Van Valen's Law) or of speciating. It was discovered that extinction risk did increase with species age in this clade when diversity dependence, climatic change and ecology were incorporated, resulting in a rejection of Van Valen's Law (Figures 3.6). Moreover, species are most likely to speciate when they are young, reinforcing the early burst model of diversification (in a clade's history rapid expansion is seen early on, which then slows due to diversity dependence). The models show that speciation is more affected by biotic controls and the reverse is true for extinction and that highest clade growth was during greenhouse conditions and when the oceans were highly stratified.

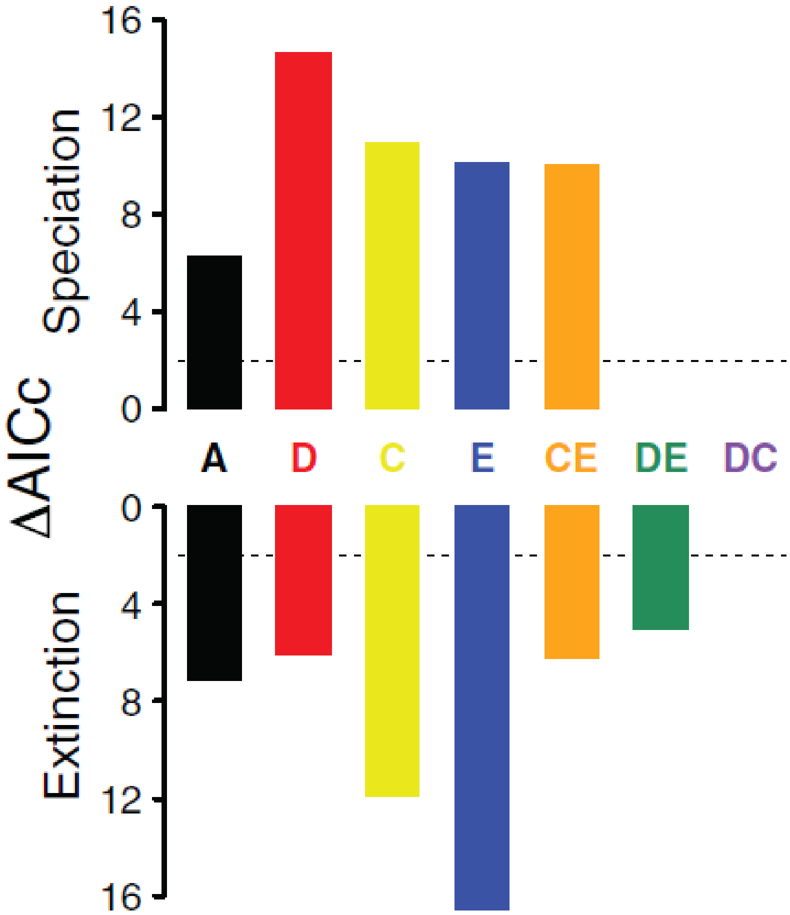

Figure 3.6 Speciation probability and extinction risk varied significantly with species' age (A), diversity, (D), climate (C), species' ecology (E) and their interactions (letter combinations). The dashed lines denote a difference in corrected Akaike Information Criterion (ΔAICc) of 2; interactions that did not match the threshold for substantial support and inclusion in the model (Burnham & Anderson, 2002) are not shown but are included in the online appendix accompanying the paper.

In conclusion, species with different ecologies have different responses to different impacts of climate change and diversity, consequently assigning a carrying capacity to an assemblage without incorporating these ecological differences will limit macroevolutionary understanding. It is the interaction of abiotic and biotic variables that drives macroevolutionary dynamics. In addition, approaches based only on extant taxa will miss the influence of extinct interspecies competition. This will limit the understanding of how biotic interactions between species affects past diversity in response to climate change and emphasizes the importance of using the fossil record for evolutionary analysis.

Appendix 4. Contents of Electronic appendix

Part A - PDF images of the phylogenies colour coded with morphogroups information

Part B - PDF images of the phylogenies colour coded with ecogroup information

Part C - Data to produce the phylogenies in R

Part D - Power analysis for sample size for the Cope's rule test of Chapter 4

Part E - The data and images used for Chapter 4

Aze et al. – a phylogeny of Cenozoic macroperforate planktonic foraminifera from fossil data

Figures illustrating the assignment of the different morphospecies and lineages within the phylogenies (budding/bifurcating morphospecies phylogeny, fully bifurcating lineage phylogeny and budding/bifurcating lineage phylogeny) to their respective morphogroups.

Spinose, flat	e.g.: *Turborotalita*
Spinose, globular	e.g.: *Subbotina, Globigerina, Globoturborotalita*
Spinose, globular with supplementary apertures	e.g.: *Globigerinoides, Globigerinatheka, Guembilitriodes*
Spinose, spherical	e.g.: *Praeorbulina, Orbulina, Orbulinoides, Globigerinatheka*
Spinose, clavate	e.g.: *Beella*
Spinose, planispiral	e.g.: *Globigerinella*
Non–spinose, globular	e.g.: *Globoquadrina*
Non–spinose, globular and keeled	e.g.: *Pulleniatina spectabilis*
Non–spinose, planispiral	e.g.: *Pseudohastigerina*
Non–spinose, tubulospinate	e.g.: *Hantkenina*
Non–spinose, keeled spines	e.g.: *Astrorotalia*
Non–spinose, turborotaliform and keeled	e.g.: *Turborotalia, Truncorotalia, Fohsella*
Non–spinose, turborotaliform and non–keeled	e.g.: *Hedbergella*
Non–spinose, globorotaliform and keeled	e.g.: *Menardella*
Non–spinose, globorotaliform and anguloconical	e.g. some *Truncorotalia*
Non–spinose, globorotaliform and non–keeled	e.g.: *Hirsutella*
Non–spinose, muricate and acarininiform	e.g.: *Acarinina*
Non–spinose, muricocarinate and keeled	e.g.: *Morozovella, Morozovelloides*
Non–spinose, muricocarinate and anguloconical	e.g.: *Morozovella, Morozovelloides*

Budding/Bifurcating Morphospecies Phylogeny

Fully Bifurcating Lineage Phylogeny

Budding/Bifurcating Lineage Phylogeny

Aze et al. – a phylogeny of Cenozoic macroperforate planktonic foraminifera from fossil data

Figures illustrating the assignment of the different morphospecies and lineages within the phylogenies (budding/bifurcating morphospecies phylogeny, fully bifurcating lineage phylogeny and budding/bifurcating lineage phylogeny) to their respective ecogroups.

- Open ocean mixed layer tropical/subtropical, with symbionts
- Open ocean mixed layer tropical/subtropical, without symbionts
- Open ocean thermocline
- Open ocean sub−thermocline
- High latitude
- Upwelling/high productivity

Budding/Bifurcating Morphospecies Phylogeny

Fully Bifurcating Lineage Phylogeny

Budding/Bifurcating Lineage Phylogeny

Species code	Ancestor code	Start date	End date	Species name
t229	n227	55.4	55.3	*Acarinina africana*
n246	n244	53.2	50.4	*Acarinina alticonica*
t247	n246	50.4	47	*Acarinina alticonica*
n231	n230	55.7	50.8	*Acarinina angulosa*
t232	n231	50.8	46.4	*Acarinina angulosa*
t243	n241	50.4	48.7	*Acarinina aspensis*
n259	n258	49.8	49	*Acarinina boudreauxi*
n261	n259	49	47	*Acarinina boudreauxi*
t262	n261	47	43.7	*Acarinina boudreauxi*
t260	n259	49	40.5	*Acarinina bullbrooki*
n283	n281	56.5	50.8	*Acarinina coalingensis*
t284	n283	50.8	50.1	*Acarinina coalingensis*
n238	n237	50.45	42.5	*Acarinina collactea*
t239	n238	42.5	30.3	*Acarinina collactea*
t233	n231	50.8	44	*Acarinina cuneicamerata*
t250	n248	43.2	31.8	*Acarinina echinata*
n252	n251	56.3	55.7	*Acarinina esnaensis*
t253	n252	55.7	51.2	*Acarinina esnaensis*
n225	n224	55.8	55.45	*Acarinina esnehensis*
n226	n225	55.45	50.4	*Acarinina esnehensis*
n235	n234	54	52.3	*Acarinina interposita*
t236	n235	52.3	50.4	*Acarinina interposita*
n266	n264	49.25	48.7	*Acarinina mcgowrani*
t280	n266	48.7	38	*Acarinina mcgowrani*
n222	n220	59.25	56.4	*Acarinina mckannai*
t223	n222	56.4	56.3	*Acarinina mckannai*
t240	n238	42.5	35.8	*Acarinina medizzai*
n219	n217	59.5	59.4	*Acarinina nitida*
n281	n219	59.4	56.5	*Acarinina nitida*
n251	n281	56.5	56.3	*Acarinina nitida*
t282	n251	56.3	56.2	*Acarinina nitida*
n237	n235	52.3	50.45	*Acarinina pentacamerata*
n241	n237	50.45	50.4	*Acarinina pentacamerata*
t242	n241	50.4	47	*Acarinina pentacamerata*
n267	n266	48.7	48.1	*Acarinina praetopilensis*
n275	n267	48.1	43.2	*Acarinina praetopilensis*
t276	n275	43.2	40	*Acarinina praetopilensis*
n285	n283	50.8	39	*Acarinina primitiva*
t286	n285	39	38.8	*Acarinina primitiva*
n248	n246	50.4	43.2	*Acarinina pseudosubsphaerica*
t249	n248	43.2	42.3	*Acarinina pseudosubsphaerica*
n256	n254	55.5	54	*Acarinina pseudotopilensis*
n258	n256	54	49.8	*Acarinina pseudotopilensis*
n264	n258	49.8	49.25	*Acarinina pseudotopilensis*
t265	n264	49.25	47.25	*Acarinina pseudotopilensis*
t263	n261	47	40.5	*Acarinina punctocarinata*
t257	n256	54	50.4	*Acarinina quetra*
t279	n277	42.8	38.2	*Acarinina rohri*
n227	n225	55.45	55.4	*Acarinina sibaiyaensis*
t228	n227	55.4	55.3	*Acarinina sibaiyaensis*
n224	n222	56.4	55.8	*Acarinina soldadoensis*

n230	n224	55.8	55.7	*Acarinina soldadoensis*
n234	n230	55.7	54	*Acarinina soldadoensis*
n244	n234	54	53.2	*Acarinina soldadoensis*
t245	n244	53.2	46.4	*Acarinina soldadoensis*
n217	n215	60.8	59.5	*Acarinina strabocella*
t218	n217	59.5	59.3	*Acarinina strabocella*
n220	n219	59.4	59.25	*Acarinina subsphaerica*
t221	n220	59.25	54.2	*Acarinina subsphaerica*
n277	n275	43.2	42.8	*Acarinina topilensis*
t278	n277	42.8	40.3	*Acarinina topilensis*
n254	n252	55.7	55.5	*Acarinina wilcoxensis*
t255	n254	55.5	50.9	*Acarinina wilcoxensis*
t198	n196	49.55	47.55	*Astrorotalia palmerae*
n666	n635	5	0.3	*Beella digitata*
t637	n666	0.3	0	*Beella digitata*
t667	n666	0.3	0	*Beella megastoma*
n635	n634	12.4	5	*Beella praedigitata*
t636	n635	5	0.8	*Beella praedigitata*
t455	n453	39	34.3	*Catapsydrax africanus*
t459	n458	37.6	17.3	*Catapsydrax dissimilis*
t457	n456	40.4	34.3	*Catapsydrax globiformis*
n453	n452	44.35	39	*Catapsydrax howei*
t454	n453	39	33.7	*Catapsydrax howei*
t464	n462	17.1	10.9	*Catapsydrax parvulus*
n462	n460	27.5	17.1	*Catapsydrax stainforthi*
t463	n462	17.1	16.9	*Catapsydrax stainforthi*
n452	n451	55	44.35	*Catapsydrax unicavus*
n456	n452	44.35	40.4	*Catapsydrax unicavus*
n458	n456	40.4	37.6	*Catapsydrax unicavus*
n460	n458	37.6	27.5	*Catapsydrax unicavus*
t461	n460	27.5	17.3	*Catapsydrax unicavus*
t672	n668	16.4	12.1	*Clavatorella bermudezi*
t374	n373	47.22	42.7	*Clavigerinella akersi*
n377	n375	44.6	44.5	*Clavigerinella caucasica*
t378	n377	44.5	44.45	*Clavigerinella caucasica*
t370	n369	47.4	43.3	*Clavigerinella colombiana*
n369	n367	48.1	47.4	*Clavigerinella eocanica*
n371	n369	47.4	47.25	*Clavigerinella eocanica*
n373	n371	47.25	47.22	*Clavigerinella eocanica*
n375	n373	47.22	44.6	*Clavigerinella eocanica*
t376	n375	44.6	34	*Clavigerinella eocanica*
t372	n371	47.25	43.3	*Clavigerinella jarvisi*
t399	n397	36.4	33.7	*Cribrohantkenina inflata*
t332	n330	23.7	3	*Dentoglobigerina altispira*
t350	n349	32	3.3	*Dentoglobigerina baroemoensis*
t339	n337	26	18.8	*Dentoglobigerina binaiensis*
n287	n285	39	37.2	*Dentoglobigerina galavisi*
n325	n287	37.2	35.4	*Dentoglobigerina galavisi*
n327	n325	35.4	34	*Dentoglobigerina galavisi*
n333	n327	34	33.9	*Dentoglobigerina galavisi*
n349	n333	33.9	32	*Dentoglobigerina galavisi*
n351	n349	32	27.3	*Dentoglobigerina galavisi*
t352	n351	27.3	27.2	*Dentoglobigerina galavisi*

n330	n328	27.1	23.7	*Dentoglobigerina globosa*
t331	n330	23.7	3	*Dentoglobigerina globosa*
n328	n327	34	27.1	*Dentoglobigerina globularis*
t329	n328	27.1	18.8	*Dentoglobigerina globularis*
n353	n351	27.3	25.1	*Dentoglobigerina larmeui*
t354	n353	25.1	11.2	*Dentoglobigerina larmeui*
n342	n340	33.3	33.2	*Dentoglobigerina prasaepis*
t343	n342	33.2	23.8	*Dentoglobigerina prasaepis*
t326	n325	35.4	27.4	*Dentoglobigerina pseudovenezuelana*
t345	n344	30	24.3	*Dentoglobigerina rohri*
n337	n335	33.4	26	*Dentoglobigerina sellii*
t338	n337	26	24.1	*Dentoglobigerina sellii*
n334	n333	33.9	33.7	*Dentoglobigerina sp*
n340	n334	33.7	33.3	*Dentoglobigerina sp*
t341	n340	33.3	32.9	*Dentoglobigerina sp*
n335	n334	33.7	33.4	*Dentoglobigerina tapuriensis*
t336	n335	33.4	25.5	*Dentoglobigerina tapuriensis*
n344	n342	33.2	30	*Dentoglobigerina venezuelana*
n346	n344	30	4.2	*Dentoglobigerina venezuelana*
t347	n346	4.2	3.3	*Dentoglobigerina venezuelana*
n480	n478	64.9	61.2	*Eoglobigerina edita*
t481	n480	61.2	61.15	*Eoglobigerina edita*
n477	n151	64.97	64.92	*Eoglobigerina eobulloides*
n478	n477	64.92	64.9	*Eoglobigerina eobulloides*
t479	n478	64.9	63.6	*Eoglobigerina eobulloides*
t482	n480	61.2	60.9	*Eoglobigerina spiralis*
t294	n293	17	16.4	*Fohsella birnageae*
n300	n298	13.4	13.3	*Fohsella fohsi*
t301	n300	13.3	11.9	*Fohsella fohsi*
n307	n305	13.7	13.6	*Fohsella lenguaensis*
t309	n307	13.6	6.7	*Fohsella lenguaensis*
n302	n300	13.3	13.1	*Fohsella lobata*
t303	n302	13.1	11.9	*Fohsella lobata*
t308	n307	13.6	9.3	*Fohsella paralenguaensis*
n297	n295	14.3	13.8	*Fohsella peripheroacuta*
n305	n297	13.8	13.7	*Fohsella peripheroacuta*
t306	n305	13.7	13.4	*Fohsella peripheroacuta*
n293	n291	22	17	*Fohsella peripheroronda*
n295	n293	17	14.3	*Fohsella peripheroronda*
t296	n295	14.3	13.8	*Fohsella peripheroronda*
n298	n297	13.8	13.4	*Fohsella praefohsi*
t299	n298	13.4	13.1	*Fohsella praefohsi*
t304	n302	13.1	11.9	*Fohsella robusta*
n16	n2	64.95	64.9	*Globanomalina archeocompressa*
n4	n16	64.9	62.9	*Globanomalina archeocompressa*
t3	n4	62.9	62.8	*Globanomalina archeocompressa*
n33	n32	55.88	48.7	*Globanomalina australiformis*
t34	n33	48.7	43.8	*Globanomalina australiformis*
n11	n10	59.45	56.3	*Globanomalina chapmani*
t12	n11	56.3	53.7	*Globanomalina chapmani*
n6	n4	62.9	61.1	*Globanomalina compressa*
t5	n6	61.1	60.7	*Globanomalina compressa*
n10	n6	61.1	59.45	*Globanomalina ehrenbergi*

n8	n10	59.45	59.4	*Globanomalina ehrenbergi*
t7	n8	59.4	59.38	*Globanomalina ehrenbergi*
n20	n18	62.05	56.5	*Globanomalina imitata*
n32	n20	56.5	55.88	*Globanomalina imitata*
t19	n32	55.88	55.8	*Globanomalina imitata*
n24	n22	55.7	55.3	*Globanomalina luxorensis*
t23	n24	55.3	54.45	*Globanomalina luxorensis*
n22	n20	56.5	55.7	*Globanomalina ovalis*
t21	n22	55.7	55.3	*Globanomalina ovalis*
n18	n16	64.9	62.05	*Globanomalina planocompressa*
t17	n18	62.05	62	*Globanomalina planocompressa*
n14	n11	56.3	50.8	*Globanomalina planoconica*
t13	n14	50.8	50.6	*Globanomalina planoconica*
t9	n8	59.4	55.9	*Globanomalina pseudomenardii*
t622	n620	29.4	22.5	*Globigerina angulisuturalis*
n653	n651	14.8	2.5	*Globigerina bulloides*
t654	n653	2.5	0	*Globigerina bulloides*
n620	n618	31.2	29.4	*Globigerina ciperoensis*
t621	n620	29.4	19.3	*Globigerina ciperoensis*
t646	n644	21.5	0.6	*Globigerina druryi*
n644	n643	26.3	21.5	*Globigerina eamesi*
t645	n644	21.5	2	*Globigerina eamesi*
t650	n649	18.4	0	*Globigerina falconensis*
n617	n615	43.5	33.8	*Globigerina officinalis*
n618	n617	33.8	31.2	*Globigerina officinalis*
t619	n618	31.2	23.8	*Globigerina officinalis*
n623	n617	33.8	31.2	*Globigerina praebulloides*
n647	n623	31.2	27	*Globigerina praebulloides*
n643	n647	27	26.3	*Globigerina praebulloides*
n649	n643	26.3	18.4	*Globigerina praebulloides*
n651	n649	18.4	14.8	*Globigerina praebulloides*
t652	n651	14.8	4.8	*Globigerina praebulloides*
t655	n653	2.5	0.6	*Globigerina umbilicata*
t425	n424	44	36.3	*Globigerinatheka barri*
n411	n409	43.95	42.8	*Globigerinatheka curryi*
t412	n411	42.8	41.6	*Globigerinatheka curryi*
n413	n411	42.8	40.5	*Globigerinatheka euganea*
n415	n413	40.5	40.3	*Globigerinatheka euganea*
t416	n415	40.3	40.2	*Globigerinatheka euganea*
n428	n426	43.8	39.1	*Globigerinatheka index*
t429	n428	39.1	34.3	*Globigerinatheka index*
t423	n422	44.3	35.5	*Globigerinatheka korotkovi*
n409	n408	44.41	43.95	*Globigerinatheka kugleri*
t410	n409	43.95	39.8	*Globigerinatheka kugleri*
t417	n415	40.3	34.3	*Globigerinatheka luterbacheri*
n419	n418	44.4	38.5	*Globigerinatheka mexicana*
t420	n419	38.5	36	*Globigerinatheka mexicana*
t421	n419	38.5	35.8	*Globigerinatheka semiinvoluta*
n408	n406	45.95	44.41	*Globigerinatheka subconglobata*
n418	n408	44.41	44.4	*Globigerinatheka subconglobata*
n422	n418	44.4	44.3	*Globigerinatheka subconglobata*
n424	n422	44.3	44	*Globigerinatheka subconglobata*
n426	n424	44	43.8	*Globigerinatheka subconglobata*

t427	n426	43.8	39.6	*Globigerinatheka subconglobata*
t430	n428	39.1	33.8	*Globigerinatheka tropicalis*
t642	n640	0.7	0	*Globigerinella adamsi*
n640	n638	4.4	0.7	*Globigerinella calida*
t641	n640	0.7	0	*Globigerinella calida*
n628	n623	31.2	29.4	*Globigerinella obesa*
n624	n628	29.4	23.2	*Globigerinella obesa*
t625	n624	23.2	15.6	*Globigerinella obesa*
n626	n624	23.2	12.5	*Globigerinella praesiphonifera*
t627	n626	12.5	11.7	*Globigerinella praesiphonifera*
n634	n626	12.5	12.4	*Globigerinella siphonifera*
n638	n634	12.4	4.4	*Globigerinella siphonifera*
t639	n638	4.4	0	*Globigerinella siphonifera*
n529	n528	22	21.95	*Globigerinoides altiapertura*
t530	n529	21.95	16.4	*Globigerinoides altiapertura*
n549	n548	18.2	16.4	*Globigerinoides bisphericus*
t550	n549	16.4	15.6	*Globigerinoides bisphericus*
t535	n533	7.5	0	*Globigerinoides conglobatus*
t539	n538	17.3	14.8	*Globigerinoides diminutus*
t532	n531	8.3	1.6	*Globigerinoides extremus*
t564	n562	3.6	2	*Globigerinoides fistulosus*
t537	n536	18	12.1	*Globigerinoides mitra*
n531	n529	21.95	8.3	*Globigerinoides obliquus*
n533	n531	8.3	7.5	*Globigerinoides obliquus*
t534	n533	7.5	1.3	*Globigerinoides obliquus*
t566	n565	21.5	16.4	*Globigerinoides parawoodi*
t648	n647	27	18.8	*Globigerinoides primordius*
n542	n540	15.1	9.6	*Globigerinoides ruber*
t544	n542	9.6	0	*Globigerinoides ruber*
n562	n560	10.9	3.6	*Globigerinoides sacculifer*
t563	n562	3.6	0	*Globigerinoides sacculifer*
t543	n542	9.6	5.3	*Globigerinoides seigliei*
n528	n526	23	22	*Globigerinoides subquadratus*
n536	n528	22	18	*Globigerinoides subquadratus*
n538	n536	18	17.3	*Globigerinoides subquadratus*
n540	n538	17.3	15.1	*Globigerinoides subquadratus*
t541	n540	15.1	10.8	*Globigerinoides subquadratus*
n548	n546	22.6	18.2	*Globigerinoides trilobus*
n560	n548	18.2	10.9	*Globigerinoides trilobus*
t561	n560	10.9	0	*Globigerinoides trilobus*
n58	n56	16.4	6	*Globoconella conoidea*
t59	n58	6	5.7	*Globoconella conoidea*
n60	n58	6	5.6	*Globoconella conomiozea*
t61	n60	5.6	5.5	*Globoconella conomiozea*
t70	n68	2.6	0	*Globoconella inflata*
n56	n55	18.3	16.4	*Globoconella miozea*
t57	n56	16.4	11.2	*Globoconella miozea*
t65	n63	5.05	3.9	*Globoconella pliozea*
n68	n66	4.6	2.6	*Globoconella puncticulata*
t69	n68	2.6	2.3	*Globoconella puncticulata*
n66	n62	5.4	4.6	*Globoconella sphericomiozea*
t67	n66	4.6	4.5	*Globoconella sphericomiozea*
n62	n60	5.6	5.4	*Globoconella terminalis*

n63	n62	5.4	5.05	*Globoconella terminalis*
t64	n63	5.05	5	*Globoconella terminalis*
t348	n346	4.2	0	*Globoquadrina conglomerata*
t355	n353	25.1	4.8	*Globoquadrina dehiscens*
t97	n96	5.7	0.2	*Globorotalia flexuosa*
n92	n88	11	6.4	*Globorotalia merotumida*
t93	n92	6.4	5.8	*Globorotalia merotumida*
n94	n92	6.4	5.8	*Globorotalia plesiotumida*
t95	n94	5.8	4.5	*Globorotalia plesiotumida*
n96	n94	5.8	5.7	*Globorotalia tumida*
n98	n96	5.7	4.9	*Globorotalia tumida*
t99	n98	4.9	0	*Globorotalia tumida*
t100	n98	4.9	0	*Globorotalia ungulata*
t674	n631	18.6	16.4	*Globorotalia zealandica*
n467	n465	47	32.5	*Globorotaloides eovariabilis*
n469	n996	26.3	17.3	*Globorotaloides eovariabilis*
n996	n467	32.5	26.3	*Globorotaloides eovariabilis*
n471	n469	17.3	17.1	*Globorotaloides eovariabilis*
t472	n471	17.1	16	*Globorotaloides eovariabilis*
n668	n469	17.3	16.4	*Globorotaloides hexagonus*
t470	n668	16.4	0	*Globorotaloides hexagonus*
n451	n450	55.2	55	*Globorotaloides quadrocameratus*
n465	n451	55	47	*Globorotaloides quadrocameratus*
t466	n465	47	33.7	*Globorotaloides quadrocameratus*
t468	n467	32.5	22.5	*Globorotaloides testarugosa*
t473	n471	17.1	4.8	*Globorotaloides variabilis*
t520	n518	34.5	23.8	*Globoturborotalita anguliofficinalis*
t591	n589	10.9	1.3	*Globoturborotalita apertura*
n500	n498	55.4	44.4	*Globoturborotalita bassriverensis*
n513	n500	44.4	44	*Globoturborotalita bassriverensis*
n514	n513	44	43.1	*Globoturborotalita bassriverensis*
t515	n514	43.1	42.4	*Globoturborotalita bassriverensis*
n584	n583	12.5	9	*Globoturborotalita bollii*
t585	n584	9	2.3	*Globoturborotalita bollii*
n526	n525	23.8	23	*Globoturborotalita brazieri*
t527	n526	23	15.1	*Globoturborotalita brazieri*
n546	n545	23	22.6	*Globoturborotalita connecta*
t547	n546	22.6	16.8	*Globoturborotalita connecta*
n578	n577	15	3.6	*Globoturborotalita decoraperta*
t579	n578	3.6	2	*Globoturborotalita decoraperta*
n518	n516	35.3	34.5	*Globoturborotalita gnaucki*
t519	n518	34.5	30.3	*Globoturborotalita gnaucki*
t586	n584	9	5.3	*Globoturborotalita kennetti*
t524	n522	30.4	16.3	*Globoturborotalita labiacrassata*
n521	n513	44	30.6	*Globoturborotalita martini*
n522	n521	30.6	30.4	*Globoturborotalita martini*
t523	n522	30.4	30.3	*Globoturborotalita martini*
t588	n587	12.1	4.3	*Globoturborotalita nepenthes*
n516	n514	43.1	35.3	*Globoturborotalita ouachitaensis*
t517	n516	35.3	23.8	*Globoturborotalita ouachitaensis*
n580	n578	3.6	2.4	*Globoturborotalita rubescens*
t581	n580	2.4	0	*Globoturborotalita rubescens*
t582	n580	2.4	0	*Globoturborotalita tenella*

n525	n521	30.6	23.8	*Globoturborotalita woodi*
n545	n525	23.8	23	*Globoturborotalita woodi*
n565	n545	23	21.5	*Globoturborotalita woodi*
n567	n565	21.5	18.1	*Globoturborotalita woodi*
n577	n567	18.1	15	*Globoturborotalita woodi*
n583	n577	15	12.5	*Globoturborotalita woodi*
n587	n583	12.5	12.1	*Globoturborotalita woodi*
n589	n587	12.1	10.9	*Globoturborotalita woodi*
t590	n589	10.9	2.4	*Globoturborotalita woodi*
n406	n404	46.4	45.95	*Guembelitrioides nuttalli*
t407	n406	45.95	42.3	*Guembelitrioides nuttalli*
n395	n393	39.8	38.1	*Hantkenina alabamensis*
t396	n395	38.1	33.7	*Hantkenina alabamensis*
t388	n387	42.3	38.1	*Hantkenina australis*
n391	n389	41.2	40	*Hantkenina compressa*
n393	n391	40	39.8	*Hantkenina compressa*
t394	n393	39.8	33.7	*Hantkenina compressa*
n387	n385	43.9	42.3	*Hantkenina dumblei*
n389	n387	42.3	41.2	*Hantkenina dumblei*
t390	n389	41.2	39	*Hantkenina dumblei*
t384	n383	43.91	41.4	*Hantkenina lehneri*
n383	n381	44.2	43.91	*Hantkenina liebusi*
n385	n383	43.91	43.9	*Hantkenina liebusi*
t386	n385	43.9	39.7	*Hantkenina liebusi*
n381	n379	44.41	44.2	*Hantkenina mexicana*
t382	n381	44.2	43.8	*Hantkenina mexicana*
n397	n395	38.1	36.4	*Hantkenina nanggulanensis*
t398	n397	36.4	33.7	*Hantkenina nanggulanensis*
t392	n391	40	33.7	*Hantkenina primitiva*
n379	n377	44.5	44.41	*Hantkenina singanoae*
t380	n379	44.41	44.4	*Hantkenina singanoae*
n150	NA	70.6	69.2	*Hedbergella holmdelensis*
n2	n150	69.2	64.95	*Hedbergella holmdelensis*
t1	n2	64.95	64.9	*Hedbergella holmdelensis*
n356	n150	69.2	65	*Hedbergella monmouthensis*
n151	n356	65	64.97	*Hedbergella monmouthensis*
n152	n151	64.97	64.9	*Hedbergella monmouthensis*
t153	n152	64.9	64.85	*Hedbergella monmouthensis*
t149	n147	2	0	*Hirsutella bermudezi*
n102	n101	15.15	10.9	*Hirsutella challengeri*
t103	n102	10.9	10	*Hirsutella challengeri*
n108	n107	7.2	5.7	*Hirsutella cibaoensis*
n132	n108	5.7	5.55	*Hirsutella cibaoensis*
t133	n132	5.55	4.4	*Hirsutella cibaoensis*
t141	n139	4.8	3.9	*Hirsutella evoluta*
t661	n660	14.99	8.8	*Hirsutella gigantea*
t146	n144	3	0	*Hirsutella hirsuta*
t104	n102	10.9	4.8	*Hirsutella juanai*
n139	n138	5.89	4.8	*Hirsutella margaritae*
n142	n139	4.8	3.5	*Hirsutella margaritae*
n144	n142	3.5	3	*Hirsutella margaritae*
t145	n144	3	2.95	*Hirsutella margaritae*
n136	n135	8.2	5.9	*Hirsutella praemargaritae*

t137	n136	5.9	5.7	*Hirsutella praemargaritae*
n631	n53	18.8	18.6	*Hirsutella praescitula*
n55	n631	18.6	18.3	*Hirsutella praescitula*
n71	n55	18.3	15.6	*Hirsutella praescitula*
n101	n71	15.6	15.15	*Hirsutella praescitula*
n105	n101	15.15	15	*Hirsutella praescitula*
t106	n105	15	14.8	*Hirsutella praescitula*
n138	n136	5.9	5.89	*Hirsutella primitiva*
t140	n138	5.89	4.8	*Hirsutella primitiva*
n660	n105	15	14.99	*Hirsutella scitula*
n135	n660	14.99	8.2	*Hirsutella scitula*
n107	n135	8.2	7.2	*Hirsutella scitula*
n147	n107	7.2	2	*Hirsutella scitula*
t148	n147	2	0	*Hirsutella scitula*
t143	n142	3.5	0	*Hirsutella theyeri*
t166	n165	60.05	55.9	*Igorina albeari*
t175	n173	45.4	43.6	*Igorina anapetes*
n173	n171	55.6	45.4	*Igorina broedermanni*
t174	n173	45.4	43.7	*Igorina broedermanni*
n171	n169	55.8	55.6	*Igorina lodoensis*
t172	n171	55.6	50.5	*Igorina lodoensis*
n165	n161	60.95	60.05	*Igorina pusilla*
n167	n165	60.05	60	*Igorina pusilla*
t168	n167	60	59.5	*Igorina pusilla*
n169	n167	60	55.8	*Igorina tadjikistanensis*
t170	n169	55.8	55.4	*Igorina tadjikistanensis*
n72	n71	15.6	14.6	*Menardella archeomenardii*
t73	n72	14.6	14.2	*Menardella archeomenardii*
n85	n83	5.7	3.2	*Menardella exilis*
t86	n85	3.2	1.9	*Menardella exilis*
t91	n89	0.2	0	*Menardella fimbriata*
n79	n76	11.4	7.5	*Menardella limbata*
n77	n79	7.5	6.5	*Menardella limbata*
n83	n77	6.5	5.7	*Menardella limbata*
t84	n83	5.7	2.3	*Menardella limbata*
n76	n74	12.31	11.4	*Menardella menardii*
n88	n76	11.4	11	*Menardella menardii*
n89	n88	11	0.2	*Menardella menardii*
t90	n89	0.2	0	*Menardella menardii*
t82	n80	3.3	2.4	*Menardella miocenica*
t78	n77	6.5	2.2	*Menardella multicamerata*
t87	n85	3.2	1.7	*Menardella pertenius*
n74	n72	14.6	12.31	*Menardella praemenardii*
t75	n74	12.31	12.3	*Menardella praemenardii*
n80	n79	7.5	3.3	*Menardella pseudomiocenica*
t81	n80	3.3	2.4	*Menardella pseudomiocenica*
t188	n186	59.15	54.45	*Morozovella acuta*
t182	n181	59.4	56.35	*Morozovella acutispira*
n199	n191	56.5	55.9	*Morozovella aequa*
t251	n199	55.9	50.8	*Morozovella aequa*
t657	n656	55.5	55.3	*Morozovella allisonensis*
n177	n176	60.95	60.8	*Morozovella angulata*
n189	n177	60.8	60	*Morozovella angulata*

t190	n189	60	59.3	*Morozovella angulata*
n191	n189	60	56.5	*Morozovella apanthesma*
n192	n191	56.5	55.9	*Morozovella apanthesma*
t193	n192	55.9	54.45	*Morozovella apanthesma*
t214	n212	52.3	43.6	*Morozovella aragonensis*
t210	n209	50.8	45.15	*Morozovella caucasica*
n178	n177	60.8	59.9	*Morozovella conicotruncata*
t179	n178	59.9	59.3	*Morozovella conicotruncata*
n209	n208	53.5	50.8	*Morozovella crater*
t211	n209	50.8	43.9	*Morozovella crater*
t659	n658	54.9	54	*Morozovella edgari*
t203	n201	54	50.4	*Morozovella formosa*
n201	n200	55.7	54	*Morozovella gracilis*
t202	n201	54	50.8	*Morozovella gracilis*
n208	n206	54	53.5	*Morozovella lensiformis*
n212	n208	53.5	52.3	*Morozovella lensiformis*
t213	n212	52.3	50.6	*Morozovella lensiformis*
t205	n204	55.55	51.6	*Morozovella marginodentata*
t184	n183	59.35	54.45	*Morozovella occlusa*
n181	n180	59.5	59.4	*Morozovella pasionensis*
n183	n181	59.4	59.35	*Morozovella pasionensis*
t185	n183	59.35	54.45	*Morozovella pasionensis*
n176	n160	61.15	60.95	*Morozovella praeangulata*
n215	n176	60.95	60.8	*Morozovella praeangulata*
t216	n215	60.8	60	*Morozovella praeangulata*
n200	n199	55.9	55.7	*Morozovella subbotinae*
n204	n200	55.7	55.55	*Morozovella subbotinae*
n206	n204	55.55	54	*Morozovella subbotinae*
t207	n206	54	50.8	*Morozovella subbotinae*
n180	n178	59.9	59.5	*Morozovella velascoensis*
n186	n180	59.5	59.15	*Morozovella velascoensis*
n656	n186	59.15	55.5	*Morozovella velascoensis*
n658	n656	55.5	54.9	*Morozovella velascoensis*
t187	n658	54.9	54.45	*Morozovella velascoensis*
n268	n267	48.1	45.9	*Morozovelloides bandyi*
t269	n268	45.9	42.3	*Morozovelloides bandyi*
n272	n270	45.4	44.65	*Morozovelloides coronatus*
t273	n272	44.65	40.1	*Morozovelloides coronatus*
n270	n268	45.9	45.4	*Morozovelloides crassatus*
t271	n270	45.4	38	*Morozovelloides crassatus*
t274	n272	44.65	40.1	*Morozovelloides lehneri*
n311	n320	9.7	6.8	*Neogloboquadrina acostaensis*
n320	n310	10.9	9.7	*Neogloboquadrina acostaensis*
t312	n311	6.8	1.7	*Neogloboquadrina acostaensis*
n53	n290	23.2	18.8	*Neogloboquadrina continuosa*
n310	n53	18.8	10.9	*Neogloboquadrina continuosa*
n318	n310	10.9	10.8	*Neogloboquadrina continuosa*
t319	n318	10.8	7.8	*Neogloboquadrina continuosa*
t324	n322	6.9	0	*Neogloboquadrina dutertrei*
n322	n320	9.7	6.9	*Neogloboquadrina humerosa*
t323	n322	6.9	1.6	*Neogloboquadrina humerosa*
t321	n318	10.8	0	*Neogloboquadrina pachyderma*
n557	n629	15.1	15.05	*Orbulina suturalis*

t630	n557	15.05	0	*Orbulina suturalis*
t559	n557	15.05	0	*Orbulina universa*
t414	n413	40.5	40	*Orbulinoides beckmanni*
t441	n439	23.2	12.6	*Paragloborotalia acrostoma*
t444	n442	18.6	13.9	*Paragloborotalia bella*
n432	n431	55.45	47.5	*Paragloborotalia griffinoides*
t434	n432	47.5	33.7	*Paragloborotalia griffinoides*
t449	n447	20.9	16.4	*Paragloborotalia incognita*
n290	n288	23.8	23.2	*Paragloborotalia kugleri*
n291	n290	23.2	22	*Paragloborotalia kugleri*
t292	n291	22	21.5	*Paragloborotalia kugleri*
n439	n438	28	23.2	*Paragloborotalia mayeri*
t440	n439	23.2	11.5	*Paragloborotalia mayeri*
n435	n432	47.5	30.5	*Paragloborotalia nana*
n445	n435	30.5	30.3	*Paragloborotalia nana*
n447	n445	30.3	20.9	*Paragloborotalia nana*
t448	n447	20.9	15.1	*Paragloborotalia nana*
t446	n445	30.3	27.1	*Paragloborotalia opima*
n288	n287	37.2	23.8	*Paragloborotalia pseudokugleri*
t289	n288	23.8	23.5	*Paragloborotalia pseudokugleri*
n436	n435	30.5	30.3	*Paragloborotalia semivera*
t437	n436	30.3	15.5	*Paragloborotalia semivera*
n438	n436	30.3	28	*Paragloborotalia siakensis*
n442	n438	28	18.6	*Paragloborotalia siakensis*
t443	n442	18.6	11.4	*Paragloborotalia siakensis*
n357	n356	65	64.9	*Parasubbotina aff_pseudobulloides*
t358	n357	64.9	64.8	*Parasubbotina aff_pseudobulloides*
n367	n366	49.25	48.1	*Parasubbotina eoclava*
t368	n367	48.1	44	*Parasubbotina eoclava*
n401	n400	48.4	48.1	*Parasubbotina griffinae*
t403	n401	48.1	37.3	*Parasubbotina griffinae*
n364	n363	55.5	51.7	*Parasubbotina inaequispira*
n366	n364	51.7	49.25	*Parasubbotina inaequispira*
n400	n366	49.25	48.4	*Parasubbotina inaequispira*
n404	n400	48.4	46.4	*Parasubbotina inaequispira*
t405	n404	46.4	45.4	*Parasubbotina inaequispira*
t365	n364	51.7	50.9	*Parasubbotina prebetica*
n359	n357	64.9	62.8	*Parasubbotina pseudobulloides*
t360	n359	62.8	59.7	*Parasubbotina pseudobulloides*
t476	n474	47.6	40.5	*Parasubbotina pseudowilsoni*
n361	n359	62.8	61	*Parasubbotina varianta*
n363	n361	61	55.5	*Parasubbotina varianta*
n431	n363	55.5	55.45	*Parasubbotina varianta*
n450	n431	55.45	55.2	*Parasubbotina varianta*
n474	n450	55.2	47.6	*Parasubbotina varianta*
t475	n474	47.6	43	*Parasubbotina varianta*
t362	n361	61	59.3	*Parasubbotina variospira*
t15	n14	50.8	45.2	*Planoglobanomalina pseudoalgeriana*
t195	n194	50.4	38	*Planorotalites capdevilensis*
n194	n192	55.9	50.4	*Planorotalites pseudoscitula*
n196	n194	50.4	49.55	*Planorotalites pseudoscitula*
t197	n196	49.55	46.4	*Planorotalites pseudoscitula*
n158	n156	62.8	61.2	*Praemurica inconstans*

t159	n158	61.2	60.9	*Praemurica inconstans*
t164	n162	60.75	43	*Praemurica lozanoi*
n156	n154	64.8	62.8	*Praemurica pseudoinconstans*
t157	n156	62.8	61.15	*Praemurica pseudoinconstans*
n154	n152	64.9	64.8	*Praemurica taurica*
t155	n154	64.8	63.8	*Praemurica taurica*
n160	n158	61.2	61.15	*Praemurica uncinata*
n161	n160	61.15	60.95	*Praemurica uncinata*
n162	n161	60.95	60.75	*Praemurica uncinata*
t163	n162	60.75	60.7	*Praemurica uncinata*
n629	n555	15.7	15.1	*Praeorbulina circularis*
t558	n629	15.1	14.9	*Praeorbulina circularis*
n553	n551	15.9	15.8	*Praeorbulina curva*
t554	n553	15.8	15	*Praeorbulina curva*
n555	n553	15.8	15.7	*Praeorbulina glomerosa*
t556	n555	15.7	15	*Praeorbulina glomerosa*
n551	n549	16.4	15.9	*Praeorbulina sicanus*
t552	n551	15.9	14.8	*Praeorbulina sicanus*
t633	n731	29.39	4	*Protentella nicobarensis*
n731	n628	29.4	29.39	*Protentella prolixa*
t632	n731	29.39	11.4	*Protentella prolixa*
t999	n997	25.7	23.8	*Protentelloides dalhousiei*
n997	n996	26.3	25.7	*Protentelloides primitiva*
t998	n997	25.7	23.8	*Protentelloides primitiva*
t402	n401	48.1	43.1	*Pseudoglobigerinella bolivariana*
n29	n28	48.1	35.8	*Pseudohastigerina micra*
t30	n29	35.8	32.2	*Pseudohastigerina micra*
t31	n29	35.8	32	*Pseudohastigerina naguewichiensis*
t26	n25	48	39.3	*Pseudohastigerina sharkriverensis*
n28	n24	55.3	48.1	*Pseudohastigerina wilcoxensis*
n25	n28	48.1	48	*Pseudohastigerina wilcoxensis*
t27	n25	48	43.3	*Pseudohastigerina wilcoxensis*
t317	n315	4.25	0	*Pulleniatina finalis*
n662	n313	5.7	5.2	*Pulleniatina obliquiloculata*
t316	n662	5.2	0	*Pulleniatina obliquiloculata*
n313	n700	6.1	5.7	*Pulleniatina praecursor*
t701	n313	5.7	1.75	*Pulleniatina praecursor*
n663	n662	5.2	4.6	*Pulleniatina praespectabilis*
t664	n663	4.6	4.4	*Pulleniatina praespectabilis*
n700	n311	6.8	6.1	*Pulleniatina primalis*
t314	n700	6.1	1.3	*Pulleniatina primalis*
n315	n663	4.6	4.25	*Pulleniatina spectabilis*
t665	n315	4.25	4.2	*Pulleniatina spectabilis*
t576	n574	5.6	0	*Sphaeroidinella dehiscens*
n568	n567	18.1	16.4	*Sphaeroidinellopsis disjuncta*
n569	n568	16.4	12.1	*Sphaeroidinellopsis disjuncta*
t571	n570	14.4	3.6	*Sphaeroidinellopsis kochi*
n574	n572	7.1	5.6	*Sphaeroidinellopsis paenedehiscens*
t575	n574	5.6	2.3	*Sphaeroidinellopsis paenedehiscens*
n570	n568	16.4	14.4	*Sphaeroidinellopsis seminulina*
n572	n570	14.4	7.1	*Sphaeroidinellopsis seminulina*
t573	n572	7.1	2.3	*Sphaeroidinellopsis seminulina*
t492	n491	42.3	28.5	*Subbotina angiporoides*

n486	n485	61.2	59.2	*Subbotina cancellata*
n487	n486	59.2	57	*Subbotina cancellata*
t488	n487	57	56.8	*Subbotina cancellata*
t599	n597	47.25	32.1	*Subbotina corpulenta*
t611	n610	46.4	40	*Subbotina crociapertura*
n596	n595	50.7	48.1	*Subbotina eocaena*
n600	n596	48.1	43.8	*Subbotina eocaena*
n602	n600	43.8	34.1	*Subbotina eocaena*
t603	n602	34.1	32.2	*Subbotina eocaena*
t614	n612	39.1	27.2	*Subbotina gortanii*
n597	n596	48.1	47.25	*Subbotina hagni*
t598	n597	47.25	34.3	*Subbotina hagni*
n498	n496	55.6	55.4	*Subbotina hornibrooki*
t499	n498	55.4	52.5	*Subbotina hornibrooki*
t601	n600	43.8	33.7	*Subbotina jacksonensis*
n491	n489	52	42.3	*Subbotina linaperta*
n493	n491	42.3	35.4	*Subbotina linaperta*
t494	n493	35.4	33.7	*Subbotina linaperta*
n489	n487	57	52	*Subbotina patagonica*
t490	n489	52	45.15	*Subbotina patagonica*
n595	n594	55.6	50.7	*Subbotina roesnaesensis*
n607	n595	50.7	50.6	*Subbotina roesnaesensis*
n609	n607	50.6	50.4	*Subbotina roesnaesensis*
n615	n609	50.4	43.5	*Subbotina roesnaesensis*
t616	n615	43.5	43.2	*Subbotina roesnaesensis*
t608	n607	50.6	38	*Subbotina senni*
n604	n602	34.1	33.8	*Subbotina sp1*
t605	n604	33.8	32.6	*Subbotina sp1*
t606	n604	33.8	27.2	*Subbotina sp2*
n594	n592	61.1	55.6	*Subbotina triangularis*
t505	n594	55.6	55.55	*Subbotina triangularis*
t484	n483	64.3	59.3	*Subbotina triloculinoides*
n483	n477	64.92	64.3	*Subbotina trivialis*
n485	n483	64.3	61.2	*Subbotina trivialis*
n592	n485	61.2	61.1	*Subbotina trivialis*
t593	n592	61.1	61	*Subbotina trivialis*
t495	n493	35.4	30.3	*Subbotina utilisindex*
n496	n486	59.2	55.6	*Subbotina velascoensis*
t497	n496	55.6	54.45	*Subbotina velascoensis*
n610	n609	50.4	46.4	*Subbotina yeguaensis*
n612	n610	46.4	39.1	*Subbotina yeguaensis*
t613	n612	39.1	33.7	*Subbotina yeguaensis*
t131	n129	0.9	0	*Truncorotalia cavernula*
t111	n110	4.3	3.5	*Truncorotalia crassaconica*
n109	n108	5.7	5.5	*Truncorotalia crassaformis*
n110	n109	5.5	4.3	*Truncorotalia crassaformis*
n112	n110	4.3	3.5	*Truncorotalia crassaformis*
t114	n112	3.5	0	*Truncorotalia crassaformis*
t134	n132	5.55	0.9	*Truncorotalia crassula*
n126	n125	1.85	1.8	*Truncorotalia excelsa*
t127	n126	1.8	0	*Truncorotalia excelsa*
t120	n118	1.8	0.4	*Truncorotalia hessi*
n115	n109	5.5	4	*Truncorotalia oceanica*

t116	n115	4	0	*Truncorotalia oceanica*
t128	n126	1.8	0	*Truncorotalia pachytheca*
n117	n115	4	3.4	*Truncorotalia ronda*
n118	n117	3.4	1.8	*Truncorotalia ronda*
t119	n118	1.8	1	*Truncorotalia ronda*
n121	n117	3.4	3.2	*Truncorotalia tenuitheca*
t122	n121	3.2	1.3	*Truncorotalia tenuitheca*
n123	n121	3.2	1.9	*Truncorotalia tosaensis*
t124	n123	1.9	1.2	*Truncorotalia tosaensis*
n125	n123	1.9	1.85	*Truncorotalia truncatulinoides*
n129	n125	1.85	0.9	*Truncorotalia truncatulinoides*
t130	n129	0.9	0	*Truncorotalia truncatulinoides*
t113	n112	3.5	1.4	*Truncorotalia viola*
t46	n45	40.8	37.2	*Turborotalia altispiroides*
n50	n49	35	32.65	*Turborotalia ampliapertura*
t52	n50	32.65	30.3	*Turborotalia ampliapertura*
n40	n39	41.8	38.6	*Turborotalia cerroazulensis*
t41	n40	38.6	33.8	*Turborotalia cerroazulensis*
n42	n40	38.6	34.1	*Turborotalia cocoaensis*
t43	n42	34.1	33.8	*Turborotalia cocoaensis*
t44	n42	34.1	33.8	*Turborotalia cunialensis*
t51	n50	32.65	30.25	*Turborotalia euapertura*
n35	n33	48.7	43.95	*Turborotalia frontosa*
n37	n35	43.95	43.2	*Turborotalia frontosa*
t38	n37	43.2	40.8	*Turborotalia frontosa*
n49	n47	39.2	35	*Turborotalia increbescens*
t54	n49	35	30.3	*Turborotalia increbescens*
n39	n37	43.2	41.8	*Turborotalia pomeroli*
n45	n39	41.8	40.8	*Turborotalia pomeroli*
n47	n45	40.8	39.2	*Turborotalia pomeroli*
t48	n47	39.2	34.6	*Turborotalia pomeroli*
t36	n35	43.95	40.8	*Turborotalia possagnoensis*
n501	n500	44.4	36	*Turborotalita carcoselleensis*
t502	n501	36	35.9	*Turborotalita carcoselleensis*
t512	n510	1.6	0	*Turborotalita clarkei*
n510	n508	4.5	1.6	*Turborotalita cristata*
t511	n510	1.6	0	*Turborotalita cristata*
n508	n506	6	4.5	*Turborotalita humilis*
t509	n508	4.5	0	*Turborotalita humilis*
n503	n501	36	25.4	*Turborotalita praequinqueloba*
t504	n503	25.4	22.4	*Turborotalita praequinqueloba*
n506	n503	25.4	6	*Turborotalita quinqueloba*
t507	n506	6	0	*Turborotalita quinqueloba*

Data required to produce all of phylogenies included in this thesis using paleoPhylo (Ezard & Purvis, 2009) a free software package to draw paleobiological phylogenies in R.

The four tabs hold different versions of our phylogeny:
aMb: fully bifurcating morphospecies phylogeny
aM: budding/bifurcating morphospecies phylogeny
aLb: fully bifurcating lineage phylogeny
aL: budding/bifurcating lineage phylogeny

Start Date gives the first occurence of the species according to the particular phylogeny; End Date gives the last occurence according to the particular phylogeny.

Species	Ancestor	Start date	End date
Acarinina africana	*Acarinina sibaiyaensis*	55.4	55.3
Acarinina alticonica	*Acarinina soldadoensis*	53.2	47
Acarinina angulosa	*Acarinina soldadoensis*	55.7	46.4
Acarinina aspensis	*Acarinina pentacamerata*	50.4	48.7
Acarinina boudreauxi	*Acarinina pseudotopilensis*	49.8	43.7
Acarinina bullbrooki	*Acarinina boudreauxi*	49	40.5
Acarinina coalingensis	*Acarinina nitida*	56.5	50.1
Acarinina collactea	*Acarinina pentacamerata*	50.45	30.3
Acarinina cuneicamerata	*Acarinina angulosa*	50.8	44
Acarinina echinata	*Acarinina pseudosubsphaer*	43.2	31.8
Acarinina esnaensis	*Acarinina nitida*	56.3	51.2
Acarinina esnehensis	*Acarinina soldadoensis*	55.8	50.4
Acarinina interposita	*Acarinina soldadoensis*	54	50.4
Acarinina mcgowrani	*Acarinina pseudotopilensis*	49.25	38
Acarinina mckannai	*Acarinina subsphaerica*	59.25	56.3
Acarinina medizzai	*Acarinina collactea*	42.5	35.8
Acarinina nitida	*Acarinina strabocella*	59.5	56.2
Acarinina pentacamerata	*Acarinina interposita*	52.3	47
Acarinina praetopilensis	*Acarinina mcgowrani*	48.7	40
Acarinina primitiva	*Acarinina coalingensis*	50.8	38.8
Acarinina pseudosubsphaerica	*Acarinina alticonica*	50.4	42.3
Acarinina pseudotopilensis	*Acarinina wilcoxensis*	55.5	47.25
Acarinina punctocarinata	*Acarinina boudreauxi*	47	40.5
Acarinina quetra	*Acarinina pseudotopilensis*	54	50.4
Acarinina rohri	*Acarinina topilensis*	42.8	38.2
Acarinina sibaiyaensis	*Acarinina esnehensis*	55.45	55.3
Acarinina soldadoensis	*Acarinina mckannai*	56.4	46.4
Acarinina strabocella	*Morozovella praeangulata*	60.8	59.3
Acarinina subsphaerica	*Acarinina nitida*	59.4	54.2
Acarinina topilensis	*Acarinina praetopilensis*	43.2	40.3
Acarinina wilcoxensis	*Acarinina esnaensis*	55.7	50.9
Astrorotalia palmerae	*Planorotalites pseudoscitula*	49.55	47.55
Beella digitata	*Beella praedigitata*	5	0
Beella megastoma	*Beella digitata*	0.3	0
Beella praedigitata	*Globigerinella siphonifera*	12.4	0.8
Catapsydrax africanus	*Catapsydrax howei*	39	34.3
Catapsydrax dissimilis	*Catapsydrax unicavus*	37.6	17.3
Catapsydrax globiformis	*Catapsydrax unicavus*	40.4	34.3
Catapsydrax howei	*Catapsydrax unicavus*	44.35	33.7
Catapsydrax parvulus	*Catapsydrax stainforthi*	17.1	10.9
Catapsydrax stainforthi	*Catapsydrax unicavus*	27.5	16.9
Catapsydrax unicavus	*Globorotaloides quadrocam*	55	17.3
Clavatorella bermudezi	*Globorotaloides hexagonus*	16.4	12.1
Clavigerinella akersi	*Clavigerinella eocanica*	47.22	42.7
Clavigerinella caucasica	*Clavigerinella eocanica*	44.6	44.45
Clavigerinella colombiana	*Clavigerinella eocanica*	47.4	43.3
Clavigerinella eocanica	*Parasubbotina eoclava*	48.1	34
Clavigerinella jarvisi	*Clavigerinella eocanica*	47.25	43.3
Cribrohantkenina inflata	*Hantkenina nanggulanensis*	36.4	33.7
Dentoglobigerina altispira	*Dentoglobigerina globosa*	23.7	3
Dentoglobigerina baroemoensi	*Dentoglobigerina galavisi*	32	3.3
Dentoglobigerina binaiensis	*Dentoglobigerina sellii*	26	18.8

Dentoglobigerina galavisi	*Acarinina primitiva*	39	27.2
Dentoglobigerina globosa	*Dentoglobigerina globularis*	27.1	3
Dentoglobigerina globularis	*Dentoglobigerina galavisi*	34	18.8
Dentoglobigerina larmeui	*Dentoglobigerina galavisi*	27.3	11.2
Dentoglobigerina prasaepis	*Dentoglobigerina sp*	33.3	23.8
Dentoglobigerina pseudovenez	*Dentoglobigerina galavisi*	35.4	27.4
Dentoglobigerina rohri	*Dentoglobigerina venezuela*	30	24.3
Dentoglobigerina sellii	*Dentoglobigerina tapuriensi*	33.4	24.1
Dentoglobigerina sp	*Dentoglobigerina galavisi*	33.9	32.9
Dentoglobigerina tapuriensis	*Dentoglobigerina sp*	33.7	25.5
Dentoglobigerina venezuelana	*Dentoglobigerina prasaepis*	33.2	3.3
Eoglobigerina edita	*Eoglobigerina eobulloides*	64.9	61.15
Eoglobigerina eobulloides	*Hedbergella monmouthensi*	64.97	63.6
Eoglobigerina spiralis	*Eoglobigerina edita*	61.2	60.9
Fohsella birnageae	*Fohsella peripheroronda*	17	16.4
Fohsella fohsi	*Fohsella praefohsi*	13.4	11.9
Fohsella lenguaensis	*Fohsella peripheroacuta*	13.7	6.7
Fohsella lobata	*Fohsella fohsi*	13.3	11.9
Fohsella paralenguaensis	*Fohsella lenguaensis*	13.6	9.3
Fohsella peripheroacuta	*Fohsella peripheroronda*	14.3	13.4
Fohsella peripheroronda	*Paragloborotalia kugleri*	22	13.8
Fohsella praefohsi	*Fohsella peripheroacuta*	13.8	13.1
Fohsella robusta	*Fohsella lobata*	13.1	11.9
Globanomalina archeocompres	*Hedbergella holmdelensis*	64.95	62.8
Globanomalina australiformis	*Globanomalina imitata*	55.88	43.8
Globanomalina chapmani	*Globanomalina ehrenbergi*	59.45	53.7
Globanomalina compressa	*Globanomalina archeocomp*	62.9	60.7
Globanomalina ehrenbergi	*Globanomalina compressa*	61.1	59.38
Globanomalina imitata	*Globanomalina planocompr*	62.05	55.8
Globanomalina luxorensis	*Globanomalina ovalis*	55.7	54.45
Globanomalina ovalis	*Globanomalina imitata*	56.5	55.3
Globanomalina planocompress	*Globanomalina archeocomp*	64.9	62
Globanomalina planoconica	*Globanomalina chapmani*	56.3	50.6
Globanomalina pseudomenard	*Globanomalina ehrenbergi*	59.4	55.9
Globigerina angulisuturalis	*Globigerina ciperoensis*	29.4	22.5
Globigerina bulloides	*Globigerina praebulloides*	14.8	0
Globigerina ciperoensis	*Globigerina officinalis*	31.2	19.3
Globigerina druryi	*Globigerina eamesi*	21.5	0.6
Globigerina eamesi	*Globigerina praebulloides*	26.3	2
Globigerina falconensis	*Globigerina praebulloides*	18.4	0
Globigerina officinalis	*Subbotina roesnaesensis*	43.5	23.8
Globigerina praebulloides	*Globigerina officinalis*	33.8	4.8
Globigerina umbilicata	*Globigerina bulloides*	2.5	0.6
Globigerinatheka barri	*Globigerinatheka subconglo*	44	36.3
Globigerinatheka curryi	*Globigerinatheka kugleri*	43.95	41.6
Globigerinatheka euganea	*Globigerinatheka curryi*	42.8	40.2
Globigerinatheka index	*Globigerinatheka subconglo*	43.8	34.3
Globigerinatheka korotkovi	*Globigerinatheka subconglo*	44.3	35.5
Globigerinatheka kugleri	*Globigerinatheka subconglo*	44.41	39.8
Globigerinatheka luterbacheri	*Globigerinatheka euganea*	40.3	34.3
Globigerinatheka mexicana	*Globigerinatheka subconglo*	44.4	36
Globigerinatheka semiinvoluta	*Globigerinatheka mexicana*	38.5	35.8
Globigerinatheka subconglobat	*Guembelitrioides nuttalli*	45.95	39.6

Globigerinatheka tropicalis	*Globigerinatheka index*	39.1	33.8
Globigerinella adamsi	*Globigerinella calida*	0.7	0
Globigerinella calida	*Globigerinella siphonifera*	4.4	0
Globigerinella obesa	*Globigerina praebulloides*	31.2	15.6
Globigerinella praesiphonifera	*Globigerinella obesa*	23.2	11.7
Globigerinella siphonifera	*Globigerinella praesiphonife*	12.5	0
Globigerinoides altiapertura	*Globigerinoides subquadrat*	22	16.4
Globigerinoides bisphericus	*Globigerinoides trilobus*	18.2	15.6
Globigerinoides conglobatus	*Globigerinoides obliquus*	7.5	0
Globigerinoides diminutus	*Globigerinoides subquadrat*	17.3	14.8
Globigerinoides extremus	*Globigerinoides obliquus*	8.3	1.6
Globigerinoides fistulosus	*Globigerinoides sacculifer*	3.6	2
Globigerinoides mitra	*Globigerinoides subquadrat*	18	12.1
Globigerinoides obliquus	*Globigerinoides altiapertura*	21.95	1.3
Globigerinoides parawoodi	*Globoturborotalita woodi*	21.5	16.4
Globigerinoides primordius	*Globigerina praebulloides*	27	18.8
Globigerinoides ruber	*Globigerinoides subquadrat*	15.1	0
Globigerinoides sacculifer	*Globigerinoides trilobus*	10.9	0
Globigerinoides seigliei	*Globigerinoides ruber*	9.6	5.3
Globigerinoides subquadratus	*Globoturborotalita brazieri*	23	10.8
Globigerinoides trilobus	*Globoturborotalita connecta*	22.6	0
Globoconella conoidea	*Globoconella miozea*	16.4	5.7
Globoconella conomiozea	*Globoconella conoidea*	6	5.5
Globoconella inflata	*Globoconella puncticulata*	2.6	0
Globoconella miozea	*Hirsutella praescitula*	18.3	11.2
Globoconella pliozea	*Globoconella terminalis*	5.05	3.9
Globoconella puncticulata	*Globoconella sphericomioze*	4.6	2.3
Globoconella sphericomiozea	*Globoconella terminalis*	5.4	4.5
Globoconella terminalis	*Globoconella conomiozea*	5.6	5
Globoquadrina conglomerata	*Dentoglobigerina venezuela*	4.2	0
Globoquadrina dehiscens	*Dentoglobigerina larmeui*	25.1	4.8
Globorotalia flexuosa	*Globorotalia tumida*	5.7	0.2
Globorotalia merotumida	*Menardella menardii*	11	5.8
Globorotalia plesiotumida	*Globorotalia merotumida*	6.4	4.5
Globorotalia tumida	*Globorotalia plesiotumida*	5.8	0
Globorotalia ungulata	*Globorotalia tumida*	4.9	0
Globorotalia zealandica	*Hirsutella praescitula*	18.6	16.4
Globorotaloides eovariabilis	*Globorotaloides quadrocam*	47	16
Globorotaloides hexagonus	*Globorotaloides eovariabilis*	17.3	0
Globorotaloides quadrocamera	*Parasubbotina varianta*	55.2	33.7
Globorotaloides testarugosa	*Globorotaloides eovariabilis*	32.5	22.5
Globorotaloides variabilis	*Globorotaloides eovariabilis*	17.1	4.8
Globoturborotalita anguliofficir	*Globoturborotalita gnaucki*	34.5	23.8
Globoturborotalita apertura	*Globoturborotalita woodi*	10.9	1.3
Globoturborotalita bassriveren	*Subbotina hornibrooki*	55.4	42.4
Globoturborotalita bollii	*Globoturborotalita woodi*	12.5	2.3
Globoturborotalita brazieri	*Globoturborotalita woodi*	23.8	15.1
Globoturborotalita connecta	*Globoturborotalita woodi*	23	16.8
Globoturborotalita decoraperta	*Globoturborotalita woodi*	15	2
Globoturborotalita gnaucki	*Globoturborotalita ouachita*	35.3	30.3
Globoturborotalita kennetti	*Globoturborotalita bollii*	9	5.3
Globoturborotalita labiacrassat	*Globoturborotalita martini*	30.4	16.3
Globoturborotalita martini	*Globoturborotalita bassrivei*	44	30.3

Globoturborotalita nepenthes	*Globoturborotalita woodi*	12.1	4.3
Globoturborotalita ouachitaens	*Globoturborotalita bassrivei*	43.1	23.8
Globoturborotalita rubescens	*Globoturborotalita decorape*	3.6	0
Globoturborotalita tenella	*Globoturborotalita rubescen*	2.4	0
Globoturborotalita woodi	*Globoturborotalita martini*	30.6	2.4
Guembelitrioides nuttalli	*Parasubbotina inaequispira*	46.4	42.3
Hantkenina alabamensis	*Hantkenina compressa*	39.8	33.7
Hantkenina australis	*Hantkenina dumblei*	42.3	38.1
Hantkenina compressa	*Hantkenina dumblei*	41.2	33.7
Hantkenina dumblei	*Hantkenina liebusi*	43.9	39
Hantkenina lehneri	*Hantkenina liebusi*	43.91	41.4
Hantkenina liebusi	*Hantkenina mexicana*	44.2	39.7
Hantkenina mexicana	*Hantkenina singanoae*	44.41	43.8
Hantkenina nanggulanensis	*Hantkenina alabamensis*	38.1	33.7
Hantkenina primitiva	*Hantkenina compressa*	40	33.7
Hantkenina singanoae	*Clavigerinella caucasica*	44.5	44.4
Hedbergella holmdelensis	NA	70.6	64.9
Hedbergella monmouthensis	*Hedbergella holmdelensis*	69.2	64.85
Hirsutella bermudezi	*Hirsutella scitula*	2	0
Hirsutella challengeri	*Hirsutella praescitula*	15.15	10
Hirsutella cibaoensis	*Hirsutella scitula*	7.2	4.4
Hirsutella evoluta	*Hirsutella margaritae*	4.8	3.9
Hirsutella gigantea	*Hirsutella scitula*	14.99	8.8
Hirsutella hirsuta	*Hirsutella margaritae*	3	0
Hirsutella juanai	*Hirsutella challengeri*	10.9	4.8
Hirsutella margaritae	*Hirsutella primitiva*	5.89	2.95
Hirsutella praemargaritae	*Hirsutella scitula*	8.2	5.7
Hirsutella praescitula	*Neogloboquadrina continuo:*	18.8	14.8
Hirsutella primitiva	*Hirsutella praemargaritae*	5.9	4.8
Hirsutella scitula	*Hirsutella praescitula*	15	0
Hirsutella theyeri	*Hirsutella margaritae*	3.5	0
Igorina albeari	*Igorina pusilla*	60.05	55.9
Igorina anapetes	*Igorina broedermanni*	45.4	43.6
Igorina broedermanni	*Igorina lodoensis*	55.6	43.7
Igorina lodoensis	*Igorina tadjikistanensis*	55.8	50.5
Igorina pusilla	*Praemurica uncinata*	60.95	59.5
Igorina tadjikistanensis	*Igorina pusilla*	60	55.4
Menardella archeomenardii	*Hirsutella praescitula*	15.6	14.2
Menardella exilis	*Menardella limbata*	5.7	1.9
Menardella fimbriata	*Menardella menardii*	0.2	0
Menardella limbata	*Menardella menardii*	11.4	2.3
Menardella menardii	*Menardella praemenardii*	12.31	0
Menardella miocenica	*Menardella pseudomiocenic*	3.3	2.4
Menardella multicamerata	*Menardella limbata*	6.5	2.2
Menardella pertenius	*Menardella exilis*	3.2	1.7
Menardella praemenardii	*Menardella archeomenardii*	14.6	12.3
Menardella pseudomiocenica	*Menardella limbata*	7.5	2.4
Morozovella acuta	*Morozovella velascoensis*	59.15	54.45
Morozovella acutispira	*Morozovella pasionensis*	59.4	56.35
Morozovella aequa	*Morozovella apanthesma*	56.5	50.8
Morozovella allisonensis	*Morozovella velascoensis*	55.5	55.3
Morozovella angulata	*Morozovella praeangulata*	60.95	59.3
Morozovella apanthesma	*Morozovella angulata*	60	54.45

Morozovella aragonensis	*Morozovella lensiformis*	52.3	43.6
Morozovella caucasica	*Morozovella crater*	50.8	45.15
Morozovella conicotruncata	*Morozovella angulata*	60.8	59.3
Morozovella crater	*Morozovella lensiformis*	53.5	43.9
Morozovella edgari	*Morozovella velascoensis*	54.9	54
Morozovella formosa	*Morozovella gracilis*	54	50.4
Morozovella gracilis	*Morozovella subbotinae*	55.7	50.8
Morozovella lensiformis	*Morozovella subbotinae*	54	50.6
Morozovella marginodentata	*Morozovella subbotinae*	55.55	51.6
Morozovella occlusa	*Morozovella pasionensis*	59.35	54.45
Morozovella pasionensis	*Morozovella velascoensis*	59.5	54.45
Morozovella praeangulata	*Praemurica uncinata*	61.15	60
Morozovella subbotinae	*Morozovella aequa*	55.9	50.8
Morozovella velascoensis	*Morozovella conicotruncata*	59.9	54.45
Morozovelloides bandyi	*Acarinina praetopilensis*	48.1	42.3
Morozovelloides coronatus	*Morozovelloides crassatus*	45.4	40.1
Morozovelloides crassatus	*Morozovelloides bandyi*	45.9	38
Morozovelloides lehneri	*Morozovelloides coronatus*	44.65	40.1
Neogloboquadrina acostaensis	*Neogloboquadrina continuos*	10.9	1.7
Neogloboquadrina continuosa	*Paragloborotalia kugleri*	23.2	7.8
Neogloboquadrina dutertrei	*Neogloboquadrina humeros*	6.9	0
Neogloboquadrina humerosa	*Neogloboquadrina acostaen*	9.7	1.6
Neogloboquadrina pachyderma	*Neogloboquadrina continuos*	10.8	0
Orbulina suturalis	*Praeorbulina circularis*	15.1	0
Orbulina universa	*Orbulina suturalis*	15.05	0
Orbulinoides beckmanni	*Globigerinatheka euganea*	40.5	40
Paragloborotalia acrostoma	*Paragloborotalia mayeri*	23.2	12.6
Paragloborotalia bella	*Paragloborotalia siakensis*	18.6	13.9
Paragloborotalia griffinoides	*Parasubbotina varianta*	55.45	33.7
Paragloborotalia incognita	*Paragloborotalia nana*	20.9	16.4
Paragloborotalia kugleri	*Paragloborotalia pseudokug*	23.8	21.5
Paragloborotalia mayeri	*Paragloborotalia siakensis*	28	11.5
Paragloborotalia nana	*Paragloborotalia griffinoides*	47.5	15.1
Paragloborotalia opima	*Paragloborotalia nana*	30.3	27.1
Paragloborotalia pseudokugler	*Dentoglobigerina galavisi*	37.2	23.5
Paragloborotalia semivera	*Paragloborotalia nana*	30.5	15.5
Paragloborotalia siakensis	*Paragloborotalia semivera*	30.3	11.4
Parasubbotina aff_pseudobullo	*Hedbergella monmouthensi*	65	64.8
Parasubbotina eoclava	*Parasubbotina inaequispira*	49.25	44
Parasubbotina griffinae	*Parasubbotina inaequispira*	48.4	37.3
Parasubbotina inaequispira	*Parasubbotina varianta*	55.5	45.4
Parasubbotina prebetica	*Parasubbotina inaequispira*	51.7	50.9
Parasubbotina pseudobulloides	*Parasubbotina* aff_pseudobu	64.9	59.7
Parasubbotina pseudowilsoni	*Parasubbotina varianta*	47.6	40.5
Parasubbotina varianta	*Parasubbotina pseudobulloi*	62.8	43
Parasubbotina variospira	*Parasubbotina varianta*	61	59.3
Planoglobanomalina pseudoalg	*Globanomalina planoconica*	50.8	45.2
Planorotalites capdevilensis	*Planorotalites pseudoscitula*	50.4	38
Planorotalites pseudoscitula	*Morozovella apanthesma*	55.9	46.4
Praemurica inconstans	*Praemurica pseudoinconsta*	62.8	60.9
Praemurica lozanoi	*Praemurica uncinata*	60.75	43
Praemurica pseudoinconstans	*Praemurica taurica*	64.8	61.15
Praemurica taurica	*Hedbergella monmouthensi*	64.9	63.8

Praemurica uncinata	*Praemurica inconstans*	61.2	60.7
Praeorbulina circularis	*Praeorbulina glomerosa*	15.7	14.9
Praeorbulina curva	*Praeorbulina sicanus*	15.9	15
Praeorbulina glomerosa	*Praeorbulina curva*	15.8	15
Praeorbulina sicanus	*Globigerinoides bisphericus*	16.4	14.8
Protentella nicobarensis	*Protentella prolixa*	29.39	4
Protentella prolixa	*Globigerinella obesa*	29.4	11.4
Protentelloides dalhousiei	*Protentelloides primitiva*	25.7	23.8
Protentelloides primitiva	*Globorotaloides eovariabilis*	26.3	23.8
Pseudoglobigerinella bolivariar	*Parasubbotina griffinae*	48.1	43.1
Pseudohastigerina micra	*Pseudohastigerina wilcoxen.*	48.1	32.2
Pseudohastigerina naguewichi(	*Pseudohastigerina micra*	35.8	32
Pseudohastigerina sharkrivere.	*Pseudohastigerina wilcoxen.*	48	39.3
Pseudohastigerina wilcoxensis	*Globanomalina luxorensis*	55.3	43.3
Pulleniatina finalis	*Pulleniatina spectabilis*	4.25	0
Pulleniatina obliquiloculata	*Pulleniatina praecursor*	5.7	0
Pulleniatina praecursor	*Pulleniatina primalis*	6.1	1.75
Pulleniatina praespectabilis	*Pulleniatina obliquiloculata*	5.2	4.4
Pulleniatina primalis	*Neogloboquadrina acostaen*	6.8	1.3
Pulleniatina spectabilis	*Pulleniatina praespectabilis*	4.6	4.2
Sphaeroidinella dehiscens	*Sphaeroidinellopsis paenede(*	5.6	0
Sphaeroidinellopsis disjuncta	*Globoturborotalita woodi*	18.1	12.1
Sphaeroidinellopsis kochi	*Sphaeroidinellopsis seminul*	14.4	3.6
Sphaeroidinellopsis paenedehi.	*Sphaeroidinellopsis seminul*	7.1	2.3
Sphaeroidinellopsis seminulina	*Sphaeroidinellopsis disjunct*	16.4	2.3
Subbotina angiporoides	*Subbotina linaperta*	42.3	28.5
Subbotina cancellata	*Subbotina trivialis*	61.2	56.8
Subbotina corpulenta	*Subbotina hagni*	47.25	32.1
Subbotina crociapertura	*Subbotina yeguaensis*	46.4	40
Subbotina eocaena	*Subbotina roesnaesensis*	50.7	32.2
Subbotina gortanii	*Subbotina yeguaensis*	39.1	27.2
Subbotina hagni	*Subbotina eocaena*	48.1	34.3
Subbotina hornibrooki	*Subbotina velascoensis*	55.6	52.5
Subbotina jacksonensis	*Subbotina eocaena*	43.8	33.7
Subbotina linaperta	*Subbotina patagonica*	52	33.7
Subbotina patagonica	*Subbotina cancellata*	57	45.15
Subbotina roesnaesensis	*Subbotina triangularis*	55.6	43.2
Subbotina senni	*Subbotina roesnaesensis*	50.6	38
Subbotina sp1	*Subbotina eocaena*	34.1	32.6
Subbotina sp2	*Subbotina* sp1	33.8	27.2
Subbotina triangularis	*Subbotina trivialis*	61.1	55.55
Subbotina triloculinoides	*Subbotina trivialis*	64.3	59.3
Subbotina trivialis	*Eoglobigerina eobulloides*	64.92	61
Subbotina utilisindex	*Subbotina linaperta*	35.4	30.3
Subbotina velascoensis	*Subbotina cancellata*	59.2	54.45
Subbotina yeguaensis	*Subbotina roesnaesensis*	50.4	33.7
Truncorotalia cavernula	*Truncorotalia truncatulinoid*	0.9	0
Truncorotalia crassaconica	*Truncorotalia crassaformis*	4.3	3.5
Truncorotalia crassaformis	*Hirsutella cibaoensis*	5.7	0
Truncorotalia crassula	*Hirsutella cibaoensis*	5.55	0.9
Truncorotalia excelsa	*Truncorotalia truncatulinoid*	1.85	0
Truncorotalia hessi	*Truncorotalia ronda*	1.8	0.4
Truncorotalia oceanica	*Truncorotalia crassaformis*	5.5	0

Truncorotalia pachytheca	*Truncorotalia excelsa*	1.8	0
Truncorotalia ronda	*Truncorotalia oceanica*	4	1
Truncorotalia tenuitheca	*Truncorotalia ronda*	3.4	1.3
Truncorotalia tosaensis	*Truncorotalia tenuitheca*	3.2	1.2
Truncorotalia truncatulinoides	*Truncorotalia tosaensis*	1.9	0
Truncorotalia viola	*Truncorotalia crassaformis*	3.5	1.4
Turborotalia altispiroides	*Turborotalia pomeroli*	40.8	37.2
Turborotalia ampliapertura	*Turborotalia increbescens*	35	30.3
Turborotalia cerroazulensis	*Turborotalia pomeroli*	41.8	33.8
Turborotalia cocoaensis	*Turborotalia cerroazulensis*	38.6	33.8
Turborotalia cunialensis	*Turborotalia cocoaensis*	34.1	33.8
Turborotalia euapertura	*Turborotalia ampliapertura*	32.65	30.25
Turborotalia frontosa	*Globanomalina australiform*	48.7	40.8
Turborotalia increbescens	*Turborotalia pomeroli*	39.2	30.3
Turborotalia pomeroli	*Turborotalia frontosa*	43.2	34.6
Turborotalia possagnoensis	*Turborotalia frontosa*	43.95	40.8
Turborotalita carcoselleensis	*Globoturborotalita bassriver*	44.4	35.9
Turborotalita clarkei	*Turborotalita cristata*	1.6	0
Turborotalita cristata	*Turborotalita humilis*	4.5	0
Turborotalita humilis	*Turborotalita quinqueloba*	6	0
Turborotalita praequinqueloba	*Turborotalita carcoselleensi*	36	22.4
Turborotalita quinqueloba	*Turborotalita praequinquelo*	25.4	0

Lineage code	Ancestor code	Start date	End date
N1	NA	70.6	69.2
N101	N76	60.8	60.2
N102	N99	59.4	56.2
N103	N102	56.2	55.7
N104	N103	55.7	55.45
N106	N104	55.45	55.4
N109	N103	55.7	52.6
N110	N109	52.6	49.55
N112	N110	49.55	41.6
N115	N109	52.6	51.6
N117	N115	51.6	50.8
N119	N117	50.8	43.2
N122	N51	7.2	2
N125	N99	59.4	56.2
N126	N125	56.2	39
N128	N125	56.2	54.6
N13	N5	55.88	48.7
N130	N128	54.6	53.2
N131	N130	53.2	47.25
N133	N131	47.25	44.65
N136	N131	47.25	45
N137	N136	45	44.5
N139	N137	44.5	44
N142	N136	45	44.35
N144	N142	44.35	41.7
N145	N144	41.7	41
N149	N126	39	37.2
N15	N13	48.7	40
N150	N149	37.2	23.2
N151	N150	23.2	22
N152	N151	22	13.1
N156	N23	18.8	10.8

N157	N156	10.8	8
N160	N157	8	5.7
N163	N149	37.2	34.4
N165	N163	34.4	32.7
N166	N165	32.7	32.1
N168	N166	32.1	25.5
N17	N15	40	37.3
N171	N165	32.7	32.5
N172	N171	32.5	29.5
N175	N171	32.5	27.3
N177	N175	27.3	27.2
N179	N175	27.3	24.1
N18	N17	37.3	34.5
N182	N2	64.9	62.3
N184	N182	62.3	60.5
N186	N184	60.5	55.5
N187	N186	55.5	55.2
N188	N187	55.2	54.5
N190	N187	55.2	53.5
N191	N188	54.5	46.15
N193	N191	46.15	30.5
N195	N193	30.5	29.8
N198	N2	64.9	64.87
N199	N190	53.5	44.5
N2	N256	64.95	64.9
N201	N199	44.5	30.4
N203	N295	15.8	13.8
N206	N190	53.5	43.4
N207	N206	43.4	37.9
N21	N17	37.3	32.9
N210	N206	43.4	39.4
N212	N210	39.4	27.5
N215	N186	55.5	51.5
N217	N215	51.5	49.25

N218	N217	49.25	48.1
N220	N218	48.1	47.2
N221	N220	47.2	44.6
N223	N221	44.6	43.7
N225	N223	43.7	41.3
N227	N225	41.3	37.5
N23	N150	23.2	18.8
N231	N217	49.25	47.55
N232	N231	47.55	45.25
N235	N231	47.55	46.4
N237	N235	46.4	43.95
N239	N237	43.95	43.9
N240	N239	43.9	43.85
N241	N240	43.85	38
N244	N240	43.85	43.75
N246	N244	43.75	43
N248	N246	43	38.4
N25	N23	18.8	18.3
N251	N239	43.9	43.75
N253	N251	43.75	40.3
N256	N1	69.2	64.95
N257	N256	64.95	64.8
N259	N257	64.8	63.7
N26	N25	18.3	15.15
N261	N259	63.7	61.2
N262	N261	61.2	55.6
N264	N262	55.6	49.55
N265	N264	49.55	48.4
N267	N264	49.55	45.7
N269	N267	45.7	42.8
N27	N25	18.3	5.3
N271	N269	42.8	33.4
N273	N271	33.4	32.9
N276	N265	48.4	47.55

N278	N276	47.55	30.5
N279	N278	30.5	27.6
N281	N278	30.5	30.2
N283	N281	30.2	28.9
N285	N283	28.9	25
N286	N285	25	23.2
N291	N285	25	21.5
N292	N298	10.2	0.3
N295	N998	26.3	15.8
N298	N366	29.4	10.2
N3	N1	69.2	62
N30	N32	14.8	14.6
N300	N298	10.2	3.8
N301	N300	3.8	0.3
N305	N261	61.2	58.7
N306	N305	58.7	55.4
N308	N306	55.4	54.5
N310	N305	58.7	38.5
N314	N308	54.5	44.15
N315	N314	44.15	4.5
N318	N314	44.15	42.4
N319	N318	42.4	34.5
N32	N26	15.15	14.8
N322	N318	42.4	30.3
N324	N322	30.3	23.8
N325	N324	23.8	22.7
N326	N325	22.7	21
N327	N326	21	7.5
N329	N327	7.5	3.3
N332	N326	21	17.5
N334	N332	17.5	15.1
N336	N324	23.8	22.5
N337	N336	22.5	17
N339	N337	17	3.3

N34	N30	14.6	10.3
N342	N336	22.5	21.1
N344	N342	21.1	17.3
N345	N344	17.3	11.5
N348	N344	17.3	14.3
N349	N348	14.3	2
N35	N34	10.3	6.5
N352	N348	14.3	12.1
N354	N352	12.1	11.5
N358	N227	37.5	36.4
N364	N160	5.7	5.2
N366	N281	30.2	29.4
N368	N80	58.8	55.5
N37	N35	6.5	5.7
N370	N368	55.5	54.5
N4	N3	62	59.38
N40	N34	10.3	10
N42	N40	10	5.8
N45	N42	5.8	3.2
N47	N32	14.8	8.2
N48	N47	8.2	3.5
N5	N3	62	55.88
N51	N47	8.2	7.2
N52	N51	7.2	5.7
N54	N52	5.7	5.5
N56	N52	5.7	4.3
N58	N56	4.3	3.4
N59	N58	3.4	1
N6	N5	55.88	45.25
N62	N58	3.4	1.4
N64	N62	1.4	0.8
N68	N198	64.87	61.15
N69	N68	61.15	60.9
N70	N69	60.9	60.75

N72	N69	60.9	59.5
N76	N68	61.15	60.8
N77	N265	48.4	45.35
N79	N80	58.8	58
N8	N6	45.25	35.8
N80	N101	60.2	58.8
N83	N101	60.2	55.9
N84	N83	55.9	55.85
N86	N84	55.85	49.55
N88	N83	55.9	54.5
N89	N88	54.5	54.1
N90	N89	54.1	54
N94	N90	54	52.4
N98	N94	52.4	47.19
N99	N76	60.8	59.4
N998	N201	30.4	26.3
T10	N8	35.8	32
T100	N102	56.2	54.2
T105	N104	55.45	50.4
T107	N106	55.4	55.3
T108	N106	55.4	55.3
T11	N4	59.38	55.9
T111	N110	49.55	48.7
T113	N112	41.6	30.3
T114	N112	41.6	35.8
T116	N115	51.6	44
T118	N117	50.8	46.4
T12	N4	59.38	45.2
T120	N119	43.2	42.3
T121	N119	43.2	31.8
T123	N122	2	0
T124	N122	2	0
T127	N126	39	38.8
T129	N128	54.6	50.9

T132	N130	53.2	50.4
T134	N133	44.65	40.5
T135	N133	44.65	40.5
T138	N137	44.5	40.1
T14	N13	48.7	43.8
T140	N142	44.35	38
T141	N139	44	42.3
T143	N139	44	38
T146	N145	41	40.3
T147	N145	41	38.2
T148	N144	41.7	40.3
T153	N151	22	21.5
T154	N152	13.1	11.9
T155	N152	13.1	6.7
T158	N157	8	0
T159	N156	10.8	0
T16	N15	40	37.2
T161	N160	5.7	1.7
T162	N364	5.2	0
T164	N163	34.4	27.4
T167	N166	32.1	25.5
T169	N168	25.5	24.1
T170	N168	25.5	18.8
T173	N172	29.5	24.3
T174	N172	29.5	0
T176	N177	27.2	3
T178	N177	27.2	3.3
T180	N179	24.1	11.2
T181	N179	24.1	4.8
T183	N182	62.3	59.7
T185	N184	60.5	59.3
T189	N188	54.5	40.5
T19	N18	34.5	33.8
T192	N191	46.15	33.7

T194	N193	30.5	11.4
T196	N195	29.8	27.1
T197	N195	29.8	15.1
T20	N18	34.5	33.8
T200	N199	44.5	33.7
T202	N201	30.4	22.5
T204	N203	13.8	4.8
T205	N203	13.8	0
T208	N207	37.9	33.7
T209	N207	37.9	34.3
T211	N210	39.4	34.3
T213	N212	27.5	17.3
T214	N212	27.5	10.9
T216	N215	51.5	50.9
T219	N218	48.1	44
T22	N21	32.9	30.25
T222	N220	47.2	42.7
T224	N223	43.7	41.4
T226	N225	41.3	38.1
T228	N227	37.5	33.7
T229	N358	36.4	33.7
T230	N358	36.4	33.7
T233	N232	45.25	37.3
T234	N232	45.25	43.1
T236	N235	46.4	45.4
T238	N237	43.95	42.3
T24	N21	32.9	30.3
T242	N241	38	36
T243	N241	38	35.8
T245	N244	43.75	36.3
T247	N246	43	35.5
T249	N248	38.4	34.3
T250	N248	38.4	33.8
T252	N251	43.75	39.8

T254	N253	40.3	40
T255	N253	40.3	34.3
T258	N257	64.8	60.9
T260	N259	63.7	59.3
T263	N262	55.6	55.55
T266	N77	45.35	27.2
T268	N267	45.7	32.1
T270	N269	42.8	33.7
T272	N271	33.4	32.2
T274	N273	32.9	32.6
T275	N273	32.9	27.2
T277	N276	47.55	38
T28	N27	5.3	3.9
T280	N279	27.6	19.3
T282	N279	27.6	22.5
T284	N283	28.9	23.8
T287	N286	23.2	18.8
T288	N286	23.2	0
T29	N27	5.3	0
T294	N292	0.3	0
T297	N295	15.8	12.1
T299	N292	0.3	0
T302	N301	0.3	0
T303	N301	0.3	0
T304	N300	3.8	0
T307	N306	55.4	54.45
T309	N308	54.5	52.5
T31	N30	14.6	14.2
T313	N310	38.5	30.3
T316	N315	4.5	0
T317	N315	4.5	0
T320	N319	34.5	23.8
T321	N319	34.5	23.8
T323	N322	30.3	16.3

T328	N327	7.5	0
T33	N26	15.15	4.8
T330	N329	3.3	1.3
T331	N329	3.3	1.6
T333	N332	17.5	12.1
T335	N334	15.1	0
T338	N337	17	0
T340	N339	3.3	2
T341	N339	3.3	0
T343	N342	21.1	16.4
T346	N345	11.5	3.6
T347	N345	11.5	0
T350	N349	2	0
T351	N349	2	0
T353	N352	12.1	2.3
T355	N354	11.5	4.3
T356	N354	11.5	1.3
T357	N86	49.55	47.55
T359	N310	38.5	28.5
T36	N35	6.5	2.2
T360	N334	15.1	10.8
T361	N325	22.7	15.1
T362	N221	44.6	34
T363	N77	45.35	40
T365	N364	5.2	0
T367	N366	29.4	4
T369	N368	55.5	55.3
T371	N370	54.5	54
T372	N291	21.5	2
T373	N291	21.5	0.6
T38	N37	5.7	1.7
T39	N37	5.7	2.4
T41	N42	5.8	4.5
T43	N45	3.2	0

T44	N40	10	0
T46	N45	3.2	0
T49	N48	3.5	0
T50	N48	3.5	0
T53	N54	5.5	4.4
T55	N54	5.5	0.9
T57	N56	4.3	3.5
T60	N59	1	0.4
T61	N59	1	0
T63	N62	1.4	1.2
T65	N64	0.8	0
T66	N64	0.8	0
T67	N198	64.87	64.85
T7	N6	45.25	39.3
T71	N70	60.75	60.7
T73	N72	59.5	55.9
T74	N72	59.5	43.6
T75	N70	60.75	43
T78	N370	54.5	54.45
T81	N79	58	54.45
T82	N79	58	55.45
T85	N84	55.85	50.8
T87	N86	49.55	38
T9	N8	35.8	32.2
T91	N89	54.1	51.6
T92	N88	54.5	50.4
T93	N90	54	50.8
T95	N94	52.4	43.6
T96	N98	47.19	43.9
T97	N98	47.19	45.15
T999	N998	26.3	23.8

Species
in lineage
Hedbergella holmdelensis
Morozovella praeangulata-Morozovella angulata
Acarinina subsphaerica
Acarinina mckannai-Acarinina soldadoensis
Acarinina esnehensis
Acarinina sibaiyaensis
Acarinina soldadoensis
Acarinina interposita-Acarinina pentacamerata
Acarinina pentacamerata-Acarinina collactea
Acarinina soldadoensis
Acarinina soldadoensis
Acarinina alticonica-Acarinina pseudosubsphaerica
Hirsutella scitula
Acarinina nitida
Acarinina coalingensis-Acarinina primitiva
Acarinina esnaensis-Acarinina wilcoxensis
Globanomalina australiformis
Acarinina pseudotopilensis
Acarinina pseudotopilensis
Acarinina boudreauxi-Acarinina bullbrooki
Acarinina praetopilensis-Acarinina mcgowrani
Morozovelloides bandyi-Morozovelloides coronatus-Morozovelloides crassatus
Morozovelloides bandyi-Morozovelloides coronatus-Morozovelloides crassatus
Acarinina praetopilensis
Acarinina praetopilensis-Acarinina topilensis
Acarinina topilensis
Dentoglobigerina galavisi
Turborotalia frontosa-Turborotalia possagnoensis-Turborotalia pomeroli-Turborotalia cerroazulensis-Turborotalia altispiroides
Paragloborotalia pseudokugleri-Paragloborotalia kugleri
Paragloborotalia kugleri
Fohsella peripheroronda-Fohsella birnageae-Fohsella peripheroacuta-Fohsella praefohsi
Neogloboquadrina continuosa

Neogloboquadrina continuosa-Neogloboquadrina acostaensis
Neogloboquadrina continuosa-Neogloboquadrina acostaensis
Dentoglobigerina galavisi
Dentoglobigerina sp-Dentoglobigerina galavisi-Dentoglobigerina tapuriensis
Dentoglobigerina tapuriensis
Dentoglobigerina sellii
Turborotalia pomeroli-Turborotalia increbescens-Turborotalia cerroazulensis
Dentoglobigerina galavisi
Dentoglobigerina prasaepis-Dentoglobigerina venezuelana-Globoquadrina conglomerata
Dentoglobigerina galavisi
Dentoglobigerina galavisi
Dentoglobigerina larmeui
Turborotalia pomeroli-Turborotalia cerroazulensis
Parasubbotina aff_pseudobulloides-Parasubbotina varianta
Parasubbotina varianta
Parasubbotina varianta
Parasubbotina varianta
Parasubbotina varianta
Globorotaloides quadrocameratus
Paragloborotalia griffinoides
Paragloborotalia nana
Paragloborotalia nana
Hedbergella monmouthensis
Globorotaloides quadrocameratus
Hedbergella monmouthensis
Globorotaloides eovariabilis
Globorotaloides hexagonus
Catapsydrax unicavus
Catapsydrax howei
Turborotalia increbescens-Turborotalia ampliapertura
Catapsydrax unicavus
Catapsydrax unicavus-Catapsydrax dissimilis
Parasubbotina inaequispira
Parasubbotina inaequispira

Parasubbotina eoclava
Clavigerinella eocanica
Clavigerinella eocanica
Clavigerinella caucasica-Hantkenina singanoae-Hantkenina mexicana-Hantkenina lehneri-Hantkenina liebusi
Hantkenina liebusi-Hantkenina dumblei
Hantkenina dumblei-Hantkenina compressa-Hantkenina primitiva
Neogloboquadrina continuosa
Parasubbotina inaequispira
Parasubbotina griffinae
Parasubbotina inaequispira
Guembelitrioides nuttalli
Globigerinatheka subconglobata
Globigerinatheka subconglobata
Globigerinatheka mexicana
Globigerinatheka subconglobata
Globigerinatheka subconglobata
Globigerinatheka index
Hirsutella praescitula-Globorotalia zealandica
Globigerinatheka kugleri
Globigerinatheka curryi-Globigerinatheka euganea
Hedbergella monmouthensis
Eoglobigerina eobulloides
Subbotina trivialis
Hirsutella praescitula-Globorotalia zealandica
Subbotina trivialis
Subbotina trivialis-Subbotina triangularis
Subbotina roesnaesensis
Subbotina roesnaesensis
Subbotina eocaena
Subbotina eocaena
Globoconella miozea-Globoconella conoidea-Globoconella conomiozea-Globoconella terminalis
Subbotina eocaena
Subbotina sp1
Subbotina roesnaesensis

Subbotina roesnaesensis-Globigerina officinalis
Globigerina ciperoensis
Globigerina officinalis-Globigerina praebulloides
Globigerina officinalis-Globigerina praebulloides
Globigerina praebulloides
Globigerina praebulloides
Globigerina eamesi
Beella praedigitata-Beella digitata-Beella megastoma
Globorotaloides eovariabilis
Globigerinella obesa-Globigerinella praesiphonifera-Globigerinella siphonifera
Hedbergella holmdelensis-Globanomalina archeocompressa-Globanomalina planocompressa
Menardella archeomenardii
Globigerinella siphonifera
Globigerinella calida
Subbotina cancellata
Subbotina velascoensis
Subbotina hornibrooki
Subbotina cancellata-Subbotina patagonica-Subbotina linaperta
Globoturborotalita bassriverensis
Turborotalita carcoselleensis-Turborotalita praequinqueloba-Turborotalita quinqueloba
Globoturborotalita bassriverensis
Globoturborotalita ouachitaensis
Hirsutella praescitula
Globoturborotalita martini
Globoturborotalita woodi
Globoturborotalita brazieri
Globigerinoides subquadratus
Globigerinoides altiapertura-Globigerinoides obliquus
Globigerinoides obliquus
Globigerinoides subquadratus
Globigerinoides subquadratus-Globigerinoides diminutus
Globoturborotalita woodi
Globoturborotalita connecta-Globigerinoides trilobus
Globigerinoides trilobus-Globigerinoides sacculifer

Menardella praemenardii-Menardella menardii
Globoturborotalita woodi
Globoturborotalita woodi
Sphaeroidinellopsis disjuncta-Sphaeroidinellopsis seminulina
Globoturborotalita woodi
Globoturborotalita decoraperta-Globoturborotalita rubescens-Globoturborotalita tenella
Menardella limbata
Globoturborotalita woodi
Globoturborotalita woodi
Hantkenina alabamensis
Pulleniatina primalis-Pulleniatina praecursor-Pulleniatina obliquiloculata
Globigerinella obesa-Globigerinella praesiphonifera-Globigerinella siphonifera
Morozovella velascoensis
Menardella limbata
Morozovella velascoensis
Globanomalina compressa-Globanomalina ehrenbergi
Menardella menardii
Globorotalia merotumida-Globorotalia plesiotumida
Globorotalia tumida-Globorotalia flexuosa
Hirsutella scitula-Hirsutella gigantea
Hirsutella praemargaritae-Hirsutella primitiva-Hirsutella evoluta-Hirsutella margaritae
Globanomalina planocompressa-Globanomalina imitata-Globanomalina ovalis
Hirsutella scitula-Hirsutella gigantea
Hirsutella cibaoensis
Hirsutella cibaoensis
Truncorotalia crassaformis
Truncorotalia crassaformis-Truncorotalia oceanica-Truncorotalia ronda
Truncorotalia crassaformis-Truncorotalia viola-Truncorotalia oceanica-Truncorotalia ronda
Globanomalina ovalis-Globanomalina luxorensis-Pseudohastigerina wilcoxensis
Truncorotalia tenuitheca-Truncorotalia tosaensis
Truncorotalia truncatulinoides
Praemurica taurica-Praemurica pseudoinconstans-Praemurica inconstans-Praemurica uncinata
Praemurica uncinata
Praemurica uncinata

Igorina pusilla
Morozovella praeangulata-Morozovella angulata
Subbotina yeguaensis-Subbotina gortanii
Morozovella occlusa-Morozovella pasionensis-Morozovella acutispira
Pseudohastigerina wilcoxensis-Pseudohastigerina micra
Morozovella conicotruncata-Morozovella velascoensis
Morozovella angulata-Morozovella apanthesma-Morozovella aequa
Morozovella aequa
Planorotalites pseudoscitula-Planorotalites capdevilensis
Morozovella subbotinae
Morozovella subbotinae
Morozovella subbotinae
Morozovella lensiformis
Morozovella crater
Acarinina strabocella-Acarinina nitida
Globorotaloides eovariabilis
Pseudohastigerina naguewichiensis
Acarinina subsphaerica
Acarinina esnehensis
Acarinina sibaiyaensis
Acarinina africana
Globanomalina pseudomenardii
Acarinina aspensis
Acarinina collactea
Acarinina medizzai
Acarinina angulosa-Acarinina cuneicamerata
Acarinina soldadoensis
Globanomalina chapmani-Globanomalina planoconica-Planoglobanomalina pseudoalgeriana
Acarinina pseudosubsphaerica
Acarinina echinata
Hirsutella scitula
Hirsutella bermudezi
Acarinina primitiva
Acarinina esnaensis-Acarinina wilcoxensis

Acarinina quetra
Acarinina punctocarinata
Acarinina boudreauxi-Acarinina bullbrooki
Morozovelloides lehneri
Globanomalina australiformis
Acarinina mcgowrani
Morozovelloides bandyi
Morozovelloides coronatus-Morozovelloides crassatus
Acarinina topilensis
Acarinina rohri
Acarinina praetopilensis
Paragloborotalia kugleri
Fohsella fohsi-Fohsella lobata-Fohsella robusta
Fohsella paralenguaensis-Fohsella lenguaensis
Neogloboquadrina humerosa-Neogloboquadrina dutertrei
Neogloboquadrina pachyderma
Turborotalia altispiroides
Neogloboquadrina acostaensis
Pulleniatina primalis-Pulleniatina praecursor-Pulleniatina obliquiloculata
Dentoglobigerina pseudovenezuelana
Dentoglobigerina tapuriensis
Dentoglobigerina sellii
Dentoglobigerina binaiensis
Dentoglobigerina rohri
Dentoglobigerina prasaepis-Dentoglobigerina venezuelana-Globoquadrina conglomerata
Dentoglobigerina globularis-Dentoglobigerina globosa-Dentoglobigerina altispira
Dentoglobigerina baroemoensis
Dentoglobigerina larmeui
Globoquadrina dehiscens
Parasubbotina pseudobulloides
Parasubbotina variospira
Parasubbotina varianta-Parasubbotina pseudowilsoni
Turborotalia cerroazulensis
Paragloborotalia griffinoides

Paragloborotalia semivera-Paragloborotalia siakensis-Paragloborotalia bella-Paragloborotalia mayeri-Paragloborotalia acrostoma
Paragloborotalia opima
Paragloborotalia nana-Paragloborotalia incognita
Turborotalia cocoaensis-Turborotalia cunialensis
Globorotaloides quadrocameratus
Globorotaloides testarugosa
Globorotaloides variabilis
Globorotaloides eovariabilis-Globorotaloides hexagonus
Catapsydrax howei
Catapsydrax africanus
Catapsydrax globiformis
Catapsydrax unicavus-Catapsydrax dissimilis
Catapsydrax stainforthi-Catapsydrax parvulus
Parasubbotina prebetica
Parasubbotina eoclava
Turborotalia ampliapertura-Turborotalia euapertura
Clavigerinella akersi-Clavigerinella jarvisi-Clavigerinella colombiana
Hantkenina lehneri
Hantkenina australis
Hantkenina compressa-Hantkenina primitiva
Hantkenina alabamensis
Hantkenina nanggulanensis-Cribrohantkenina inflata
Parasubbotina griffinae
Pseudoglobigerinella bolivariana
Parasubbotina inaequispira
Guembelitrioides nuttalli
Turborotalia increbescens
Globigerinatheka mexicana
Globigerinatheka semiinvoluta
Globigerinatheka barri
Globigerinatheka subconglobata-Globigerinatheka korotkovi
Globigerinatheka index
Globigerinatheka tropicalis
Globigerinatheka kugleri

Globigerinatheka euganea-Orbulinoides beckmanni
Globigerinatheka luterbacheri
Eoglobigerina eobulloides-Eoglobigerina edita-Eoglobigerina spiralis
Subbotina triloculinoides
Subbotina triangularis
Subbotina yeguaensis-Subbotina gortanii
Subbotina hagni-Subbotina corpulenta
Subbotina jacksonensis
Subbotina eocaena
Subbotina sp1
Subbotina sp2
Subbotina senni
Globoconella pliozea
Globigerina ciperoensis
Globigerina angulisuturalis
Globigerina officinalis
Globigerinoides primordius
Globigerina praebulloides-Globigerina bulloides-Globigerina umbilicata-Globigerina falconensis
Globoconella sphericomiozea-Globoconella puncticulata-Globoconella inflata
Beella megastoma
Clavatorella bermudezi
Beella praedigitata-Beella digitata
Globigerinella adamsi
Globigerinella calida
Globigerinella siphonifera
Subbotina velascoensis
Subbotina hornibrooki
Menardella archeomenardii
Subbotina linaperta-Subbotina utilisindex
Turborotalita quinqueloba
Turborotalita humilis-Turborotalita cristata-Turborotalita clarkei
Globoturborotalita ouachitaensis
Globoturborotalita gnaucki-Globoturborotalita anguliofficinalis
Globoturborotalita labiacrassata

Globigerinoides conglobatus
Hirsutella challengeri-Hirsutella juanai
Globigerinoides obliquus
Globigerinoides extremus
Globigerinoides mitra
Globigerinoides ruber-Globigerinoides seigliei
Globigerinoides bisphericus-Praeorbulina sicanus-Praeorbulina curva-Praeorbulina glomerosa-Praeorbulina circularis-Orbulina suturalis-Orbulina
Globigerinoides fistulosus
Globigerinoides trilobus-Globigerinoides sacculifer
Globigerinoides parawoodi
Sphaeroidinellopsis kochi
Sphaeroidinellopsis seminulina-Sphaeroidinellopsis paenedehiscens-Sphaeroidinella dehiscens
Globoturborotalita rubescens
Globoturborotalita tenella
Globoturborotalita bollii-Globoturborotalita kennetti
Globoturborotalita nepenthes
Globoturborotalita woodi-Globoturborotalita apertura
Astrorotalia palmerae
Subbotina angiporoides
Menardella multicamerata
Globigerinoides subquadratus
Globoturborotalita brazieri
Clavigerinella eocanica
Subbotina crociapertura
Pulleniatina praespectabilis-Pulleniatina spectabilis-Pulleniatina finalis
Protentella prolixa-Protentella nicobarensis
Morozovella allisonensis
Morozovella edgari
Globigerina eamesi
Globigerina druryi
Menardella exilis-Menardella pertenius
Menardella limbata-Menardella pseudomiocenica-Menardella miocenica
Globorotalia plesiotumida
Globorotalia tumida-Globorotalia flexuosa

Menardella menardii-Menardella fimbriata
Globorotalia ungulata
Hirsutella theyeri
Hirsutella margaritae-Hirsutella hirsuta
Hirsutella cibaoensis
Truncorotalia crassula
Truncorotalia crassaconica
Truncorotalia hessi
Truncorotalia crassaformis-Truncorotalia oceanica
Truncorotalia tosaensis
Truncorotalia cavernula
Truncorotalia truncatulinoides-Truncorotalia excelsa-Truncorotalia pachytheca
Hedbergella monmouthensis
Pseudohastigerina sharkriverensis
Praemurica uncinata
Igorina albeari
Igorina tadjikistanensis-Igorina lodoensis-Igorina broedermanni-Igorina anapetes
Praemurica lozanoi
Morozovella velascoensis-Morozovella acuta
Morozovella occlusa
Morozovella pasionensis-Morozovella acutispira
Morozovella aequa
Planorotalites pseudoscitula-Planorotalites capdevilensis
Pseudohastigerina micra
Morozovella marginodentata
Morozovella gracilis-Morozovella formosa
Morozovella subbotinae
Morozovella lensiformis-Morozovella aragonensis
Morozovella crater
Morozovella caucasica
Protentelloides primitiva-Protentelloides dalhousiei

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Lineage code	Ancestor code	Start date	End date
N1-N3	NA	70.6	62
N102-T100	N99-N125	59.4	54.2
N103-N109-N1	N102-T100	56.2	46.4
N104-T105	N103-N109-N1	55.7	50.4
N106-T107	N104-T105	55.45	55.3
N110-N112-T1	N103-N109-N1	52.6	30.3
N119-T120	N103-N109-N1	50.8	42.3
N126-T127	N99-N125	56.2	38.8
N128-T129	N99-N125	56.2	50.9
N13-T14	N5-N6-N8-T9	55.88	43.8
N130-N131-N1	N128-T129	54.6	40.3
N133-T135	N130-N131-N1	47.25	40.5
N137-N139-T1	N130-N131-N1	45	38
N145-T146	N130-N131-N1	41.7	40.3
N149-N163	N126-T127	39	34.4
N15-N17	N13-T14	48.7	37.3
N150-N151-T1	N149-N163	37.2	21.5
N152-T154	N150-N151-T1	22	11.9
N23-N156-N15	N150-N151-T1	32.9	1.7
N165	N149-N163	34.4	32.7
N166-T167	N165	32.7	25.5
N168	N166-T167	32.1	25.5
N171	N165	32.7	32.5
N172	N171	32.5	29.5
N175	N171	32.5	27.3
N177	N175	27.3	27.2
N179-T180	N175	27.3	11.2
N18-T19	N15-N17	37.3	33.8
N182-T183	N256-N2-N198	64.9	59.7
N184-N186-N1	N182-T183	62.3	40.5
N190-N199-T2	N184-N186-N1	55.2	33.7
N191-T192	N184-N186-N1	54.5	33.7
N193-N195-T1	N191-T192	46.15	15.1
N201-N998-N2	N190-N199-T2	44.5	13.8
N206-N210-N2	N190-N199-T2	53.5	17.3
N207-T208	N206-N210-N2	43.4	33.7
N21-T24	N15-N17	37.3	32.9
N215-N217-N2	N184-N186-N1	55.5	45.4
N218-T219	N215-N217-N2	49.25	44
N220-N221-T3	N218-T219	48.1	34
N223-N225-N2	N220-N221-T3	44.6	33.7
N232-T233	N215-N217-N2	47.55	37.3
N237-T238	N215-N217-N2	46.4	42.3
N239-N240-N2	N237-T238	43.95	35.5
N241-T242	N239-N240-N2	43.85	36
N248-T249	N239-N240-N2	43	34.3
N25	N23-N156-N15	18.8	18.3
N251-T252	N239-N240-N2	43.9	39.8
N253-T254	N251-T252	43.75	40
N256-N2-N198	N1-N3	69.2	64.85
N257	N256-N2-N198	64.95	64.8
N259-N261-N2	N257	64.8	55.55

N26-N32	N25	18.3	14.8
N264-N265-N2	N259-N261-N2	55.6	23.8
N267	N264-N265-N2	49.55	45.7
N269	N267	45.7	42.8
N27	N25	18.3	5.3
N271-T272	N269	42.8	32.2
N273-T274	N271-T272	33.4	32.6
N279-T280	N264-N265-N2	30.5	19.3
N285-N286-T2	N264-N265-N2	28.9	0
N291-T372	N285-N286-T2	25	2
N292-T299	N366-N298-N3	10.2	0
N30	N26-N32	14.8	14.6
N301-T303	N366-N298-N3	3.8	0
N305	N259-N261-N2	61.2	58.7
N306-T307	N305	58.7	54.45
N308-T309	N306-T307	55.4	52.5
N310-T313	N305	58.7	30.3
N314-N318	N308-T309	54.5	42.4
N315-T316	N314-N318	44.15	0
N319-T320	N314-N318	42.4	23.8
N322	N314-N318	42.4	30.3
N324-N336-N3	N322	30.3	1.3
N325-T361	N324-N336-N3	23.8	15.1
N326-N332-N3	N325-T361	22.7	10.8
N327-N329-T3	N326-N332-N3	21	1.3
N337-N339-T3	N324-N336-N3	22.5	0
N34-N40-T44	N30	14.6	0
N345-T347	N324-N336-N3	17.3	0
N349-T350	N324-N336-N3	14.3	0
N35-N37-T39	N34-N40-T44	10.3	2.4
N358-T229	N223-N225-N2	37.5	33.7
N364-T162	N23-N156-N15	5.7	0
N366-N298-N3	N264-N265-N2	30.2	0
N4-T12	N1-N3	62	45.2
N42-T41	N34-N40-T44	10	4.5
N45-T43	N42-T41	5.8	0
N47	N26-N32	14.8	8.2
N48-T50	N47	8.2	0
N5-N6-N8-T9	N1-N3	62	32.2
N51-N122-T12	N47	8.2	0
N52-N54-T53	N51-N122-T12	7.2	4.4
N56-N58-N59-	N52-N54-T53	5.7	0
N62-T63	N56-N58-N59-	3.4	1.2
N64-T66	N62-T63	1.4	0
N68-N69-N70-	N256-N2-N198	64.87	60.7
N72	N68-N69-N70-	60.9	59.5
N76-N101	N68-N69-N70-	61.15	60.2
N77-T266	N264-N265-N2	48.4	27.2
N79	N80-N368-N37	58.8	58
N80-N368-N37	N76-N101	60.2	54.45
N83-N84-T85	N76-N101	60.2	50.8
N86-T87	N83-N84-T85	55.85	38
N88-N89-N90-	N83-N84-T85	55.9	50.8

N94-T95	N88-N89-N90-T	54	43.6
N98-T96	N94-T95	52.4	43.9
N99-N125	N76-N101	60.8	56.2
T10	N5-N6-N8-T9	35.8	32
T108	N106-T107	55.4	55.3
T11	N4-T12	59.38	55.9
T111	N110-N112-T1	49.55	48.7
T114	N110-N112-T1	41.6	35.8
T116	N103-N109-N1	51.6	44
T121	N119-T120	43.2	31.8
T124	N51-N122-T12	2	0
T132	N130-N131-N1	53.2	50.4
T134	N133-T135	44.65	40.5
T138	N137-N139-T1	44.5	40.1
T140	N130-N131-N1	44.35	38
T141	N137-N139-T1	44	42.3
T147	N145-T146	41	38.2
T155	N152-T154	13.1	6.7
T158	N23-N156-N15	8	0
T159	N23-N156-N15	10.8	0
T16	N15-N17	40	37.2
T164	N149-N163	34.4	27.4
T169	N168	25.5	24.1
T170	N168	25.5	18.8
T173	N172	29.5	24.3
T174	N172	29.5	0
T176	N177	27.2	3
T178	N177	27.2	3.3
T181	N179-T180	24.1	4.8
T185	N184-N186-N1	60.5	59.3
T194	N193-N195-T1	30.5	11.4
T196	N193-N195-T1	29.8	27.1
T20	N18-T19	34.5	33.8
T202	N201-N998-N2	30.4	22.5
T204	N201-N998-N2	13.8	4.8
T205	N201-N998-N2	13.8	0
T209	N207-T208	37.9	34.3
T211	N206-N210-N2	39.4	34.3
T214	N206-N210-N2	27.5	10.9
T216	N215-N217-N2	51.5	50.9
T22	N21-T24	32.9	30.25
T222	N220-N221-T3	47.2	42.7
T224	N223-N225-N2	43.7	41.4
T226	N223-N225-N2	41.3	38.1
T230	N358-T229	36.4	33.7
T234	N232-T233	45.25	43.1
T243	N241-T242	38	35.8
T245	N239-N240-N2	43.75	36.3
T250	N248-T249	38.4	33.8
T255	N253-T254	40.3	34.3
T258	N257	64.8	60.9
T260	N259-N261-N2	63.7	59.3
T268	N267	45.7	32.1

T270	N269	42.8	33.7
T275	N273-T274	32.9	27.2
T277	N264-N265-N2	47.55	38
T28	N27	5.3	3.9
T282	N279-T280	27.6	22.5
T287	N285-N286-T2	23.2	18.8
T29	N27	5.3	0
T294	N292-T299	0.3	0
T297	N201-N998-N2	15.8	12.1
T302	N301-T303	0.3	0
T31	N30	14.6	14.2
T317	N315-T316	4.5	0
T321	N319-T320	34.5	23.8
T323	N322	30.3	16.3
T328	N327-N329-T3	7.5	0
T33	N26-N32	15.15	4.8
T331	N327-N329-T3	3.3	1.6
T333	N326-N332-N3	17.5	12.1
T335	N326-N332-N3	15.1	0
T338	N337-N339-T3	17	0
T340	N337-N339-T3	3.3	2
T343	N324-N336-N3	21.1	16.4
T346	N345-T347	11.5	3.6
T351	N349-T350	2	0
T353	N324-N336-N3	12.1	2.3
T355	N324-N336-N3	11.5	4.3
T357	N86-T87	49.55	47.55
T359	N310-T313	38.5	28.5
T36	N35-N37-T39	6.5	2.2
T363	N77-T266	45.35	40
T365	N364-T162	5.2	0
T367	N366-N298-N3	29.4	4
T369	N80-N368-N37	55.5	55.3
T371	N80-N368-N37	54.5	54
T373	N291-T372	21.5	0.6
T38	N35-N37-T39	5.7	1.7
T46	N45-T43	3.2	0
T49	N48-T50	3.5	0
T55	N52-N54-T53	5.5	0.9
T57	N56-N58-N59-	4.3	3.5
T60	N56-N58-N59-	1	0.4
T65	N64-T66	0.8	0
T7	N5-N6-N8-T9	45.25	39.3
T73	N72	59.5	55.9
T74	N72	59.5	43.6
T75	N68-N69-N70-	60.75	43
T81	N79	58	54.45
T82	N79	58	55.45
T91	N88-N89-N90-	54.1	51.6
T92	N88-N89-N90-	54.5	50.4
T97	N98-T96	47.19	45.15
T999	N201-N998-N2	26.3	23.8

Power Analysis of sample size for Cope's rule test

The following power analysis was performed by Dr Thomas Ezard and concluded that a sample size of 100 was statistically able to pick up the size trends in an example lineage (Case study 1: N300 'siphonifera': T304 'siphonifera': N301 'calida').

What sample size is required?

The following four quantities have an intimate relationship:

1. sample size
2. effect size
3. significance level = P(Type I error) = probability of finding an effect that is not there
4. power = 1 - P(Type II error) = probability of finding an effect that is there

What we want to know is: how many individual specimens should be picked to allow us detect a size increase? Knowing any three of the above, lets us calculate the fourth. Let's consider significance at 0.01 and 0.05. We'll then loop through sample and effect sizes for a linear regression that is lm(area ~ speciesGroup), i.e. the maximum number of parameters used is 3 (ancestor + 2 sister species). Power analysis is implemented in R in the pwr package.

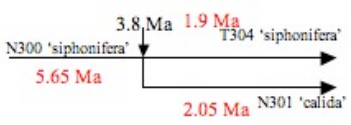
Cohen (1988) suggests f2 values of 0.02, 0.15, and 0.35 represent small, medium, and large effect sizes. Effect size is the standardized mean difference:

$$\theta = \left(\frac{\mu_1 - \mu_2}{s}\right)$$

where θ is the effect size, μ_m the mean of population m and s the standard deviation [this is Cohen's d statistic]. They are assumed equal in the original MS, but to calculate a pooled standard deviation let

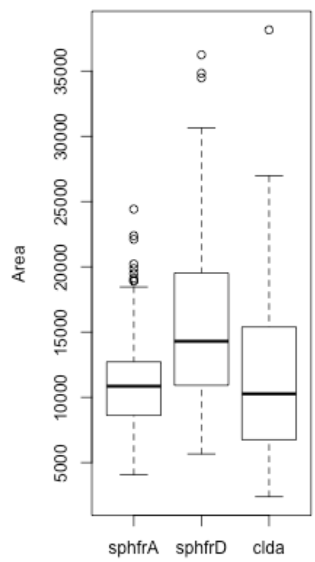
$$s = \sqrt{\frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2}}$$

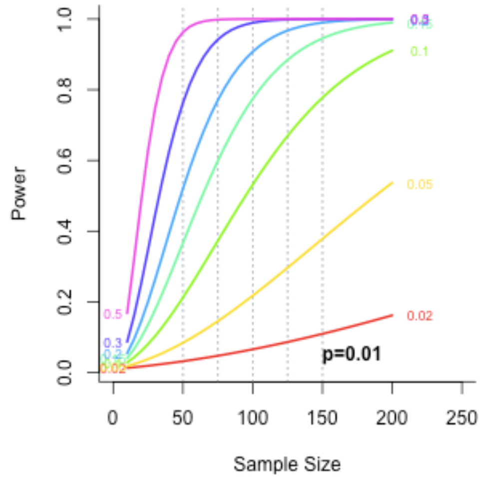
So, in the first case study:

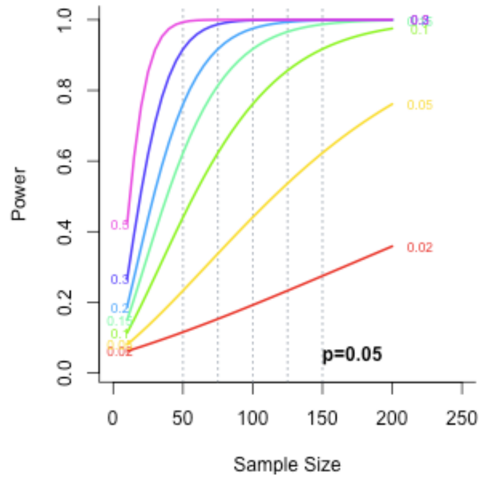


the effect sizes are (ss1='siphonifera', ss2='calida'):

```
[1] "ss1 - anc : 0.8786"
[1] "ss2 - anc : 0.0301"
```







So, for sample sizes of 50, there is about a 40% probability of detecting a moderate effect at the 1% level and about 60% probability at the 5% level. For sample sizes of 100, these probabilities rise to 80% and 90%, respectively.

Moderately-strong effect sizes (~0.3) can be picked up with approximately 80% and 90% probability for 0.01 and 0.05 levels of significance and a sample size of 50.

To get over 95% probability of detecting the *G.siphonifera* difference at p=0.05, you could've stopped at 20 individuals per group. For the *G.siphonifera* vs *G.calida* difference, you'd have needed to go on to 575 individuals per group.

A Cautionary Note.

All of these power analyses assume a straight linear model (lm), i.e. no over dispersion or changing variance functions with mean. Repeating the analyses by transforming first and then using an lm gives the same qualitative answers and with very good model diagnostics.

Analysis

To illustrate this, here's the analysis I performed.

```
m1 <- lm(sqAr ~ sp, data=cs1)
summary(m1)
Call: lm(formula = sqAr ~ sp, data = cs1)

Residuals:
    Min      1Q  Median      3Q     Max 
-55.310 -16.450  -2.116  15.276  91.196 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept) 104.8114     1.6230  64.581  < 2e-16 ***
spss1        17.8520     2.2952   7.778 3.25e-14 ***
spss2        -0.6746     2.2952  -0.294    0.769    
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 22.95 on 597 degrees of freedom
Multiple R-squared: 0.1231,   Adjusted R-squared: 0.1202
F-statistic: 41.91 on 2 and 597 DF,  p-value: < 2.2e-16
```

The *G. siphonifera* descendant (spss1) is much bigger than the ancestor, but *G. calida* (spss2) isn't significantly bigger. I reckon there are five hypotheses for how size can change over these three groups:

1. No change;
2. Both descendants are bigger, and different in size from each other;
3. Both descendants are bigger, but not different from each other;
4. Sister species 1 is bigger but sister species 2 isn't;
5. Vice versa.

So, we can set up models for these five scenarios and select the best one using AIC:

Model	DF	AIC	AIC Weight
No Change	2	5542.6	0.000
Both bigger & different from each other	4	5467.8	0.278
Both bigger & not different from each other	3	5527.9	0.000
'siphonifera' bigger	3	5465.9	0.722
'calida' bigger	3	5523.7	0.000

The conclusion here is that 'siphonifera' is bigger, but 'calida' isn't. The final model is:

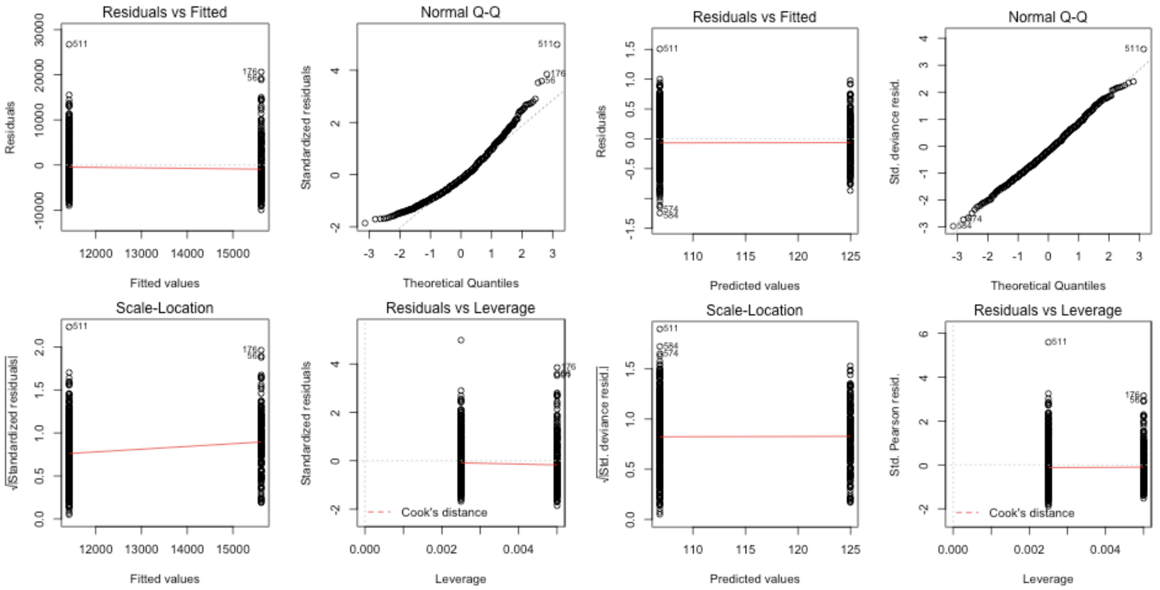
```
summary(m4)
Call: lm(formula = sqAr ~ gp1, data = cs1)

Residuals:
    Min      1Q  Median      3Q     Max 
-55.647 -16.627  -2.118  15.378  90.858 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept)  104.474      1.147  91.107   <2e-16 ***
gp11          18.189      1.986   9.158   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 22.93 on 598 degrees of freedom
Multiple R-squared: 0.123,    Adjusted R-squared: 0.1215
F-statistic: 83.87 on 1 and 598 DF,  p-value: < 2.2e-16
```

This makes various assumptions though, which can easily be addressed for more robust analysis (although the diagnostic plots look fine). Meaning the variance is not adequately modeled by the assumptions of an lm, it increases as the Area does. An easy fix for this is use a Gamma model, account for overdispersion and let the variance increase non-linearly with the mean. Re-fitting and then re-calculating the above table yields:

Model	DF	AIC	AIC	BIC	BIC

			Weight		Weight
No Change	2	-292.7	0.001	-292.7	0.005
Both bigger & different from each other	4	-291.5	0	-282.7	0
Both bigger & not different from each other	3	-290.9	0	-286.5	0
‘siphonifera’ bigger	3	-307.7	0.999	-303.3	0.995
‘calida’ bigger	3	-281.8	0	-277.4	0

The key difference being that the most complex model now has no weight at all. [It wouldn’t have considered it anyway as its AIC was worse and it used additional parameters, making it an unparsimonious choice]. So why do it? Well the model diagnostics are:



The set on the left are the lm() and the set on the right are the glm(). Note that there’s a curve in the Normal Q-Q and an upwards trend in the Scale Location on the left, but not on the right. By letting the variance increase non-linearly with the mean, we’re doing a better job of meeting all the model assumptions.

There is overwhelming evidence that ‘siphonifera’ has become larger between the two samples.

For completeness, here's the model:

```
summary(m4)
Call: glm(formula = Area ~ gp1, data = cs1,
  family = quasi(link = "sqrt", variance = "mu^2"))

Deviance Residuals:
     Min        1Q    Median        3Q       Max
-1.24501  -0.33802  -0.07767   0.22110   1.50707

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  106.845      1.121  95.346  < 2e-16 ***
gp11          18.124      2.166   8.367 4.17e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for quasi family taken to be 0.1760012)

    Null deviance: 116.62  on 599  degrees of freedom
Residual deviance: 103.11  on 598  degrees of freedom
AIC: NA
Number of Fisher Scoring iterations: 5
```

Marginally weaker effects. The R^2 analogy is (116.62-103.11)/**116**.62 = 0.116. The AIC is given as NA despite being in the table above.

Conclusion

100 is a reasonable target, as it provides enough data to up moderately-weak differences with >90% probability.

Reference

J. Cohen (1988) Statistical power analysis for the behavioral sciences. Lawrence Erlbaum Associates, publishers.

Code in R

```
##based on http://www.statmethods.net/stats/power.html
rm(list=ls(all=TRUE))
library(pwr)            #for power analysis
library(paleoTS)        #for Akaike weight function
setwd("/Users/the1/Documents/foram/azeetal/")
cs1 <- read.csv("cs1.csv", header=TRUE)

r <- seq(10,200,5)      #*#*range of sample sizes
nr <- length(r)
p <- c(0.02, 0.05, 0.1, 0.15, 0.2, 0.3, 0.5)
                        #*#*range of power values
np <- length(p)
pow <- vector("list", 2)
pow[[1]] <-  pow[[2]] <- matrix(0, nr, np)

for (i in 1:nr)
  {
  for (j in 1:np)
    {
    power <- pwr.f2.test(u = 3, v = r[i], f2=p[j],
                 sig.level = .01)
    pow[[1]][i,j] <- power$power
    power <- pwr.f2.test(u = 3, v = r[i], f2=p[j],
```

```
               sig.level = .05)
    pow[[2]][i,j] <- power$power
    }
  }

#*#*DEFINE A COLUMN OF NAs...
cs1$sp <- NA
#*#*...TO REDEFINE GROUPS INTO ANCESTOR OR SISTER-SPECIES
cs1$sp[cs1$grp==1 | cs1$grp==2] <- "ss1"
cs1$sp[cs1$grp==3 | cs1$grp==4] <- "anc"
cs1$sp[cs1$grp==5 | cs1$grp==6] <- "ss2"
cs1$sp <- as.factor(cs1$sp)
#*#*ANC IS CLEVERLY-CHOSEN HERE, BECAUSE IT IS BEFORE "s"
#*#*IN THE ALPHABET, and therefore WILL BE "INTERCEPT" IN ANALYSIS

#*#*transform area onto square root scale and get means and SDs
cs1$sqAr <- sqrt(cs1$Area)
arMn <- with(cs1, tapply(sqAr, sp, mean))
arSD <- with(cs1, tapply(sqAr, sp, sd))

#*#*[overleaf] calculate and print effect sizesfor (i in 1:3) for (j
in 1:3)
  {
    if(i>j)
    {
    plds <- sqrt(((200-1)*arSD[i]^2 + (200-1)*arSD[j]^2)/400)
    efSz <- (arMn[i] - arMn[j]) / plds
    print(paste(names(arMn)[i],"-",names(arMn)[j],
           ":",round(abs(efSz), 4)))
   }
  }
```

```
#*#*STATISTICAL ANALYSIS
#*#* define groups according to five hypotheses
cs1$gp1 <- factor(0 + (cs1$sp=="ss1"))#ss1 different from rest
cs1$gp2 <- factor(0 + (cs1$sp=="ss2"))#ss2 different from rest
cs1$gp3 <- factor(0 + (cs1$sp!="anc"))#anc different from rest

m1 <- lm(Area ~ 1, data=cs1)
m2 <- lm(Area ~ sp, data=cs1)
m3 <- lm(Area ~ gp3, data=cs1)
m4 <- lm(Area ~ gp1, data=cs1)
m5 <- lm(Area ~ gp2, data=cs1)
cs1aic <- AIC(m1,m2,m3,m4,m5)
cbind(cs1aic, wts=round(akaike.wts(cs1aic[,2]), 3))
summary(m2)
summary(m4)
```

```
m11 <- glm(Area ~ 1, data=cs1,
  family=quasi(link="sqrt", variance="mu^2"))
m12 <- glm(Area ~ sp, data=cs1,
  family=quasi(link="sqrt", variance="mu^2"))
m13 <- glm(Area ~ gp3, data=cs1,
  family=quasi(link="sqrt", variance="mu^2"))
m14 <- glm(Area ~ gp1, data=cs1,
  family=quasi(link="sqrt", variance="mu^2"))
m15 <- glm(Area ~ gp2, data=cs1,
  family=quasi(link="sqrt", variance="mu^2"))

#*#*write function for qAIC that accounts for overdispersion
#*#*nobs=2 gives AIC, change to log(n) for BIC
qaic <- function(m, nobs=2) (
  -summary(m)$deviance/2)/summary(m)$dispersion +
   nobs*(summary(m)$df.null-summary(m)$df.residual)

qaics <- c(qaic(m11),qaic(m12),qaic(m13),qaic(m14),qaic(m15))
round(qaics, 1)
round(akaike.wts(qaics), 3)
summary(m14)
```

```
#*#* make pictures
tiff("boxplot.tiff",240,480)
with(cs1, boxplot(Area ~ sp,
   names=c("sphfrA","sphfrD","clda"), ylab="Area"))
dev.off()

tiff("power.tiff", 300, 600)
cls <- rainbow(length(p))
par(mar=c(4,4,.5,.5), mfrow=c(2,1))
plot(0:1,0:1, type='n', ylim=range( pow), xlim=range(0,250),
   bty='l', xlab="Sample Size", ylab="Power")
abline(v=seq(50,150,25), lty=3, col="slategray4")
for(i in 1:7) lines(r, pow[[1]][,i], col=cls[i], type='l', lwd=2)
text(220, apply(pow[[1]], 2, max), p, col=cls, cex=.7)
text(0, apply(pow[[1]], 2, min), p, col=cls, cex=.7)
text(170,0.05, "p=0.01", font=2)

plot(0:1,0:1, type='n', ylim=range( pow), xlim=range(0,250),
   bty='l', xlab="Sample Size", ylab="Power")
abline(v=seq(50,150,25), lty=3, col="slategray4")
for(i in 1:7) lines(r, pow[[2]][,i], col=cls [i], type='l', lwd=2)
text(220, apply(pow[[2]], 2, max), p, col=cls), cex=.7)
text(5, apply(pow[[2]], 2, min), p, col=cls, cex=.7)
text(170,0.05, "p=0.05", font=2)
dev.off()

tiff("lmDiagnostics.tiff")
par(mfrow=c(2,2), mar=c(4,4,2,2)) ; plot(m4)
dev.off()

tiff("glmDiagnostics.tiff")
par(mfrow=c(2,2), mar=c(4,4,2,2)) ; plot(m14)
dev.off
```

G. siphonifera 872C 3H 1 59-61 Hole 1

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	64357.8	328.2	253.8	333.4	229.8	280.1	959.1	1.1	326.5	266.8
2	79928.2	352.3	291.7	355.3	251.2	313.7	1053.3	1.1	335.3	285.4
3	80475.3	368.4	279.2	365.1	274.7	314.7	1038.1	1.1	363.9	288.7
4	85328.7	388.7	280.7	382	262.2	323.1	1066.6	1.1	382.9	284
5	86731.5	362.9	307.5	364.5	261.6	326.9	1092.2	1.1	354.5	311
6	88274.5	383.2	294	378.1	268	330.1	1077.2	1	378.8	290.6
7	93015.8	397.6	301.9	401.9	283.1	337	1160.3	1.2	400.9	321.7
8	96045.7	408.1	303.4	399.3	281	342.8	1158.4	1.1	401.3	322.5
9	96298.2	387.9	319.3	384.3	266.4	344.1	1152.5	1.1	380.2	316.2
10	96354.3	393.3	313.9	396.7	310.7	344.9	1137.7	1.1	397.7	327.8
11	98360.2	384.2	327.2	388.1	304.6	349.3	1140.7	1.1	389	335.8
12	98795.1	397.7	318.7	396	292.5	349	1166.2	1.1	397	335.8
13	101727	411.7	316.6	407.4	304.6	354	1183.9	1.1	404.6	322.4
14	103564	423.4	314.4	418.2	285.6	356.5	1204.7	1.1	417.9	328.8
15	113510	444.9	326.4	439.8	304.6	373.2	1237.7	1.1	442.7	328.4
16	117536	457.2	330	453.4	307.9	379.6	1283.8	1.1	453.6	346
17	118602	450.4	341.1	441.8	278.4	380.4	1326.1	1.2	450.9	340.5
18	125377	433.8	372.8	434.9	296.2	393.6	1358.4	1.2	434.7	378.9
19	126331	455.8	360.9	455.4	297.4	392.6	1377.4	1.2	470.2	376.7
20	133625	478.5	356.5	471.4	326.2	406.3	1336.3	1.1	471.6	349
21	134832	464.1	375.2	467.3	320.5	407.8	1383.6	1.1	455.2	382.8
22	142434	490.2	375.6	489	326.9	417.7	1466.3	1.2	489.3	394.9
23	145436	497.6	376.1	493	353.7	423.2	1427.2	1.1	491.3	390.9
24	169830	535.4	407.2	540.6	387.5	458.1	1530.2	1.1	540.1	432.1
25	213090	605.3	452.6	592.2	394.4	512.8	1743.4	1.1	592.2	475.3

G. siphonifera 872C 3H 1 59-61 Hole 2

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	55211.9	293.7	241.8	295.2	203.8	259.8	879.2	1.1	287.6	236.5
2	55604.7	299.1	239	299.9	226.1	261	869.7	1.1	302.3	255.8
3	57750.8	303.9	242.9	300.8	230	266.4	872.7	1	301.9	248.9
4	72241.2	348.1	266.3	350.7	254.7	297.5	997.5	1.1	348.1	280.3
5	76996.5	367.2	270.2	365.1	254.7	306	1046.7	1.1	363.7	285.4
6	81541.3	362.6	288.4	362.9	275.4	316.7	1046	1.1	361.1	298.3
7	82411	370.5	285.6	361.3	258.7	317.9	1066.5	1.1	367.4	294.8
8	89873.6	391.4	293.5	393	287.8	333	1096.6	1.1	391.8	308
9	92945.6	387	308.7	385.9	292.2	338.2	1137.2	1.1	386.7	323.5
10	93675	405.4	295.9	400.5	279.7	338.9	1135.2	1.1	401.6	304
11	95147.9	399.1	306.4	391.7	279.1	341.5	1163.2	1.1	394.6	312.4
12	97153.8	409.1	303.6	402.9	280.9	345.7	1162.8	1.1	404.8	305.6
13	97602.7	403.5	310.8	406.4	293.6	346.8	1162.2	1.1	406.1	323.6
14	102106	418.4	314.4	409.1	256.3	353.2	1227.5	1.2	411.9	331.4
15	107071	413.5	333	414	315.9	363.4	1213.5	1.1	413.4	343
16	123091	430.6	367.6	435.1	349.8	390.7	1294.4	1.1	426.8	376.4
17	126219	460.3	350.8	453.2	333.5	395	1309.7	1.1	452.3	363
18	126275	474.9	341.2	462	301.9	393.7	1345.7	1.1	456.9	351.6
19	129866	460.6	361.2	486.4	345.6	400.4	1403.2	1.2	484.8	371.5
20	131717	463.9	364.3	464.8	343.7	403.2	1352.9	1.1	464.8	371.6
21	138128	465.2	381.9	462.5	327.6	413.6	1386.1	1.1	470.5	394.1
22	147316	486	391.1	492.9	354.5	426.6	1454	1.1	494.3	411
23	149139	510.3	380.5	502.3	330.7	426.6	1508.7	1.2	508.2	399.1
24	158384	514.8	395	504.6	364.9	442.1	1476.9	1.1	511.9	416.9
25	160866	511.2	402.7	508	356.3	446.4	1478.7	1.1	508.3	403

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	63123.3	315.5	256.8	319.8	227.8	278.4	926.8	1.1	318	267.4
2	64960.9	337.5	247	335.7	225.8	281	949.6	1.1	333.8	259.8
3	68061	348.3	251.7	349.9	232.2	287.9	980.5	1.1	350.3	273.2
4	70768.3	339.5	266.6	339.2	250.9	294.7	964.3	1	338.4	266.4
5	70852.5	322.2	283	329.9	263.3	295.9	975.6	1.1	332.3	293.3
6	76140.8	356.9	274.8	358.6	253.5	305.6	1035.4	1.1	359.1	289.8
7	76491.5	364.9	268.2	357.1	256.4	306	1016.1	1.1	357.1	274.4
8	80854	382.6	271.5	381.4	258.7	313.7	1064	1.1	381	285
9	81008.3	358.5	289.4	361.5	279.9	316.4	1040.9	1.1	360.2	299.9
10	84697.5	365.8	296.5	367.1	280.9	323.2	1063.6	1.1	367.5	305.4
11	87965.9	383.7	294.3	378.4	251	328.8	1111.9	1.1	378.5	305.1
12	88022	382	296.6	380.1	267.4	328	1119.7	1.1	379	304.6
13	88625.2	389.4	292.9	387.3	274	329.5	1115.2	1.1	387.3	310.4
14	92749.2	396.7	299.7	390.4	265.9	337.6	1129.2	1.1	391.3	309
15	93604.9	388.4	312	395.4	264.8	338.8	1166.7	1.2	391.5	319.6
16	96634.8	412.5	302.2	414	279.1	343.5	1183	1.2	414.5	322.3
17	103803	407.4	326.5	402	289.1	358.5	1190.8	1.1	402.3	320.9
18	123119	456	344.9	450.3	329.6	390	1288.4	1.1	448.3	352.8
19	129487	451.4	367.8	453.9	334.4	400.2	1326.2	1.1	453.9	382
20	132868	465.7	365.1	470	346.8	405.7	1353.9	1.1	469.4	389.7
21	142252	481.2	377.9	483.6	352.6	420	1379.3	1.1	481.4	390.3
22	151833	509.7	382.7	505.4	339.4	431.6	1488.6	1.2	505.8	398.6
23	156476	509.2	397.8	516.6	339.4	438.7	1516.3	1.2	506.3	422.6
24	157710	508.6	396.9	506.9	366.5	442.1	1465	1.1	507.7	400
25	168610	525.3	410.6	524.6	388.5	457.5	1503	1.1	524.6	420.8

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	71652	333.6	276.2	339.4	245.2	297.3	990.8	1.1	336	292.6
2	84627.4	370	293	370.9	283.8	322.9	1066.6	1.1	367.2	303.8
3	96115.8	383.2	322.8	387	284.7	345	1151.8	1.1	376.4	335.4
4	97153.8	394.8	316.3	396.3	273	346.3	1161.9	1.1	394.3	326.8
5	97294.1	395	316.2	390	297	346.4	1151.4	1.1	389.7	319.5
6	97504.5	407.7	308.4	404.5	284.7	345.5	1169.9	1.1	405.9	327.7
7	98795.1	409.1	308.4	402.1	293.1	349	1142.4	1.1	401.8	309.4
8	102975	422.3	312.9	421.9	293.7	355.7	1193.2	1.1	422.8	326
9	114394	449.3	325.6	442	286.6	374.7	1241	1.1	443.2	319.6
10	114506	445.8	329	438.2	290.1	375.3	1245.1	1.1	437.9	325.3
11	117466	450	333.7	444.2	312.3	380.7	1260.7	1.1	443.4	336.6
12	119570	460.2	332.6	453.9	304.6	383	1289.7	1.1	455.6	338
13	126836	452.8	360.2	456.2	336.9	395.3	1330	1.1	452.4	379.7
14	134130	456	379.5	460.8	327.2	406.9	1370.2	1.1	453.7	388.8
15	135659	477.7	363.9	474	340.8	409.1	1360	1.1	472.3	375.2
16	136318	466.5	377.5	463.6	325.8	409.3	1413.1	1.2	462.8	401.1
17	139923	491.1	366.4	485.5	323.3	414.6	1390.5	1.1	490.5	371.6
18	140751	490.8	368.3	494.6	357.4	416.5	1391.7	1.1	493.3	385.9
19	144342	497.1	371.3	485.6	328.2	421.9	1394.4	1.1	485.8	371.2
20	152548	489.8	397.8	488.2	375.4	435.7	1416.6	1	487.7	401.2
21	158650	519.3	394.6	517.9	350.2	441.9	1513.8	1.1	520.8	420.6
22	182595	562.8	416	549.4	397	474.2	1594	1.1	547.6	438.5
23	182946	546.6	431.9	563.6	370.7	474.6	1644.6	1.2	558.3	456.1
24	184629	541.3	439.7	532.6	391.3	479	1614.4	1.1	531.3	448.7
25	238115	662.2	464.2	652.3	407.2	539.7	1902.4	1.2	654.9	499.1

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	48857.5	263.3	238.3	267.4	221.1	245.4	807.3	1.1	266.4	251.5
2	51045.7	270.3	241.5	271	218.8	251.1	815.8	1	267.1	247.1
3	52939.5	266.8	254.4	277.5	237.2	255.9	836.8	1.1	276.7	266.6
4	53149.9	278.3	245.1	284.7	215.8	255.6	850.5	1.1	276.6	244
5	53668.9	282.7	244.8	290.1	230.7	256.7	855	1.1	292.4	262.7
6	54580.7	289.5	241.7	289.3	218.2	258.9	867.9	1.1	294	256.2
7	54720.9	280	250	283.4	244.6	259.8	841.9	1	287.9	254.4
8	54735	269.1	260.4	277.1	229.6	259.9	850.8	1.1	270.5	255.3
9	55885.2	282	253.6	282.4	240.2	262.7	854.7	1	284.1	256.8
10	57961.3	295.4	251.6	301.2	234.6	267	881	1.1	296.8	263.2
11	59125.5	301.4	251.3	300.5	235.1	269.9	889.4	1.1	297.5	259.3
12	60724.7	311.6	249.6	307.1	239.8	273.3	897.5	1.1	307.6	255.7
13	62632.4	311.5	258.7	317.3	248.4	277.5	924.6	1.1	314	269.7
14	64007.1	310	263.9	310.8	250.4	281.5	914.5	1	312	265.6
15	65227.5	297.8	282.8	307.9	244.9	283.1	949.5	1.1	295.3	288.7
16	65522	322.4	265.2	318.4	224.4	284	978.5	1.2	319.1	270.1
17	70571.9	320	282.2	327.4	267.4	295.6	965.3	1.1	329.5	295.9
18	70600	308.3	294.4	315.3	265.1	295.3	976.3	1.1	310.7	293.2
19	70908.6	333.7	273.5	338.8	254.7	295.1	1005.7	1.1	339.1	287.2
20	74583.7	341	280.2	336.4	266.5	303.4	992	1	333.8	278
21	77824.1	341	293	342.6	279.6	309.7	1025.4	1.1	342.3	309.9
22	79731.8	341.9	299.3	345.9	291.4	314.1	1048.3	1.1	345.9	313.5
23	83014.2	346.2	313.7	357.8	289.7	322.4	1073.7	1.1	354.5	336.2
24	83098.4	354.5	301.7	362.3	280.5	320	1073.8	1.1	360.8	316.3
25	96943.4	385.3	322.5	385.3	300.5	345.9	1138	1.1	387.2	329.4

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	43456.9	246.9	226	253.3	203.1	231.1	770.1	1.1	244.3	224.4
2	47567	259.9	234.2	264.4	223	242.1	786.8	1	263.2	241.6
3	48352.5	278.6	222.6	278.4	206.3	243.3	808.9	1.1	280.6	230
4	50695.1	280.7	232.7	276.5	204.8	248.9	841.2	1.1	284.8	237.6
5	51101.9	288.4	229.1	287.1	218.4	249.5	841.5	1.1	287.8	238.7
6	53009.6	278.4	245.1	282.5	234.6	255.4	849.7	1.1	282.1	257.5
7	53023.6	290	234.2	288.7	214.5	256.1	843.3	1.1	289.7	244.9
8	53668.9	284.8	240.7	289.4	222.3	257.6	837.3	1	288.5	251.2
9	56811	292.8	251	303.2	218.2	264.4	897.2	1.1	298.6	264.4
10	56881.1	294.8	249.7	302	209.9	263.9	899	1.1	298.2	256.2
11	57035.5	302.1	241.7	303.6	226.5	264.9	873.4	1.1	304.2	254.3
12	57049.5	309.5	236.2	310	226.4	264.2	884.6	1.1	307.7	244.3
13	57624.6	304.7	242.3	306	221.2	266.2	885.5	1.1	308.9	243.1
14	57778.9	298	249.1	298.2	236.5	266.3	883.1	1.1	298.3	260
15	57792.9	282	261.9	282.5	254.3	267.7	870.3	1	283	267
16	58971.2	309.2	245	308.6	228.3	269	893.9	1.1	306.6	253
17	60710.6	306.3	253.5	302	239.8	273.7	889.7	1	301.7	257.8
18	61650.5	292.8	270.4	302.1	253.2	275.3	904.4	1.1	297.5	281.4
19	65311.6	313.1	267.4	318.7	238.1	284.2	936.8	1.1	307.5	276.5
20	66938.8	316.4	271.2	316	239.3	287.6	943	1.1	312.9	275
21	67373.7	321.6	270.6	321.6	258.3	288.2	964.1	1.1	315	284.8
22	69042.9	326.3	272.9	351.5	260.2	290.9	1044.3	1.3	355.3	278.2
23	75215	339	284.3	341.6	272.7	305.4	1001.6	1.1	342.1	291.4
24	85497.1	341.3	321.9	350.3	281.6	325.5	1095.5	1.1	335.9	316.2
25	89508.9	373	310.2	375	276.7	331.7	1121.8	1.1	373.4	328

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	42966	267.5	205.7	260.2	196.6	229.1	760.1	1.1	258.5	206.2
2	54300.1	302.1	231	306.2	225.5	257.4	868.1	1.1	305.4	245.6
3	54524.5	273.4	255.6	273.7	229.6	259.6	844	1	273.3	253.2
4	55211.9	294	240.7	299.6	225.5	260.6	863.9	1.1	300.9	257.9
5	55520.5	271.1	262.4	282.1	226.4	261.5	862.2	1.1	269.3	268.5
6	55885.2	283.5	253.7	295.9	235.7	262	868.5	1.1	293.3	262.2
7	57484.3	288.2	256	291.8	241.7	266.4	867.3	1	288.1	254
8	58690.7	298.8	251.2	295.9	228.6	268.9	886	1.1	293.1	255.3
9	59967.2	310.2	247.5	312.7	240.8	271.2	892.1	1.1	311.5	256.3
10	60612.4	299.3	259.2	295.6	235.7	273.6	895.5	1.1	300.3	264.3
11	63011.1	297.6	271.8	296.5	259.8	278.7	906.1	1	293.2	274.2
12	63740.6	298.9	275	310.4	247.6	280	945.6	1.1	292.3	266.3
13	64245.5	330.9	249.9	322.7	234.6	280.2	944.6	1.1	323.5	261
14	65367.7	307.4	273.2	316.4	262.8	283.7	935.8	1.1	314.7	288.5
15	65367.7	305.9	274	306.3	251.8	284.3	937.1	1.1	303	278.6
16	68580	322	274.2	330	258.7	291	964.8	1.1	331.7	285.8
17	73349.3	326	288.8	335.3	271.8	301.3	995.3	1.1	337.6	307.2
18	75691.9	339.2	290	342.4	259.3	304.6	1042.1	1.1	336.9	302.5
19	78609.6	345.2	292.6	351.1	278.4	311.4	1047.6	1.1	339.6	303.8
20	79563.5	340.3	298.9	341.2	283.8	314.2	1027.5	1.1	337.2	302.5
21	82074.4	346.2	305.5	355.5	277.3	318.8	1068.1	1.1	354.1	320.8
22	82102.4	355	298.6	354.5	289	317.4	1071.7	1.1	352.6	309
23	89480.8	363.9	315.5	374.6	290.1	333.4	1108.7	1.1	374.2	327
24	103354	391.6	339.5	406.6	296.6	357.6	1202.2	1.1	397.4	353.6
25	128744	448.3	371.9	464.7	324.7	398.6	1369	1.2	462.6	402.9

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	41254.6	262.2	201.9	257	193.1	223.9	754.6	1.1	255.9	205
2	52280.2	267.3	251.1	271	226.3	254.1	843.4	1.1	268.8	248.9
3	53206	290.9	234.7	299.6	220.4	256.3	862.6	1.1	298.8	253.4
4	53654.8	267.2	257.6	278.8	221.1	257.6	861.6	1.1	267.7	255.9
5	53795.1	278.3	249.2	288.4	229.3	257.1	866.7	1.1	288.7	256.8
6	54145.8	301.5	230.9	305.2	221.2	256.6	877.6	1.1	304.9	245.1
7	55941.3	280.8	256	281.6	239.3	262.6	866	1.1	280.9	254.3
8	56923.2	294.8	247.3	302	218.2	264.6	905.8	1.1	294.8	254.2
9	58508.3	305.9	245.2	307.3	236.5	267.9	889.9	1.1	308.5	254.9
10	59630.5	296.8	257.4	294.9	226.2	270.9	901.5	1.1	299.2	264.6
11	62085.3	325.9	245.5	319.2	229.5	274.9	946.3	1.1	317.2	258.4
12	62253.6	296.2	269.9	302	254.7	277.2	933.9	1.1	298.2	273
13	62408	296.9	271.4	309.9	240.7	276.6	953.5	1.2	289.2	263.3
14	63614.3	300.8	271.6	302.5	244	280.2	936.1	1.1	300.3	284.8
15	64203.5	304.7	270.8	313.6	253.5	280.7	941.8	1.1	311.4	284.4
16	67163.2	316.1	273.9	324.7	256.9	287.4	970.8	1.1	326.7	288.2
17	70880.5	321.6	283.3	331.8	267.4	296.1	1002	1.1	333.2	302.6
18	73573.8	335.1	286.2	340.1	251.9	299.3	1056.2	1.2	334.1	304.2
19	75046.6	339.9	286.6	341.7	270.9	306.2	1042.3	1.2	337.6	299.6
20	77136.7	335.5	294.1	336.4	273.7	308.6	1018.5	1.1	332.3	297.8
21	79240.8	341.5	299.4	351.9	271.4	312.3	1057.6	1.1	349.4	314.8
22	80405.1	350.7	296.3	350.3	285.7	315.3	1082.3	1.2	349.7	309.5
23	86871.8	360	310.2	370.2	284.9	328.1	1171.6	1.3	370.9	325.7
24	100955	388.6	334.4	402.9	288.7	353.5	1207.1	1.1	393	349.2
25	127369	445.4	370.8	464.7	321.1	396.1	1374.7	1.2	460.5	400.5

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	45140.2	260.9	221.8	260	189.9	235.1	786.7	1.1	263.9	227.3
2	50779.2	291.6	225.5	290.9	180.1	250.3	856.9	1.2	283.5	225.9
3	55015.5	306	230.9	309.2	220	259.2	888.3	1.1	309.1	248
4	55604.7	286.2	249.5	288.1	219.2	261.9	865.6	1.1	285.1	253.8
5	56390.2	305.7	237.5	304.3	195.3	261.7	905.9	1.2	303.4	251
6	57372.1	290.8	252.9	290.2	241.7	266.4	880.3	1.1	295.3	255.9
7	57400.2	295.8	248.9	304.8	222.5	266	885.2	1.1	304.9	263.6
8	57750.8	298.2	250	307.1	231.2	265.7	905.8	1.1	309.4	270.8
9	59434.1	313.9	243.9	313.1	217.9	268.9	915.7	1.1	310.8	261.7
10	62730.6	304.2	266.8	307.1	241	277.3	940.9	1.1	304.2	273.5
11	63993	329.8	250.7	324.3	225.5	278.9	961.3	1.1	323.7	264.6
12	65592.2	307.8	273.8	310.3	256.3	284.4	959.3	1.1	307.5	276.2
13	66630.2	323.1	265.4	331.3	234	285.6	969.7	1.1	327.5	280.5
14	68131.1	331.2	264.4	333.5	239	289.1	969.1	1.1	330.3	280.4
15	70964.7	324.8	282	327	230.8	295.4	1015.1	1.2	330.4	291.6
16	71455.6	309.4	297	320	263.4	297.5	988.1	1.1	315.5	296
17	75411.4	341.1	284.2	338	244.3	304.9	1021.9	1.1	343.2	291.8
18	75734	344.9	283	342.1	269.7	304.7	1028.6	1.1	343.5	297.8
19	76267	339.6	287.9	343	274.7	307	1024.4	1.1	344.1	296.2
20	76603.7	361.1	271.8	357.8	243.9	306.4	1026.5	1.1	352.7	279.9
21	76659.8	334.4	298.8	342.5	252.7	306.4	1078.3	1.2	342.4	304.7
22	78034.5	350.2	285.6	349.7	269.2	310.4	1022.5	1.1	349.3	296.5
23	78230.9	338.8	296.6	342.8	284.7	311.5	1032.6	1.1	341.8	310
24	91416.6	382.4	309.9	388.8	254.7	334.5	1177.1	1.2	382.9	328.7
25	92693.1	375.7	317.4	388.4	296.6	338.6	1138.3	1.1	388.4	339.2

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	39389	249.4	203.3	251	186	219.5	737.5	1.1	249.6	211.4
2	41184.5	258.1	205.3	258.5	181.8	224.3	755.5	1.1	256.3	212.7
3	46374.6	265.1	224.4	261.9	205.2	238.7	793.1	1.1	263.7	234.9
4	49208.2	275.7	230.5	277.2	209.9	245.4	851.1	1.2	273.8	232.6
5	54833.1	298.4	236	301.1	217.7	259.1	882.9	1.1	301.5	255.6
6	55394.2	290.3	244.8	301.5	217.7	260.8	863.8	1.1	302.2	258.1
7	56334.1	279.3	260.4	291.4	221.2	262.8	889.4	1.1	283.1	263.9
8	58297.9	289.5	258.8	289.4	227.5	267.9	904.8	1.1	294.8	257
9	58340	293.5	253.7	291.7	241.7	268.4	873	1	290.8	265.2
10	59279.8	315.6	241.8	314.6	218.2	269.3	920.6	1.1	312.1	258
11	60991.2	292.7	267	295.9	236.4	274	909.3	1.1	297	269.4
12	61299.8	297	265.2	297.8	227.8	275	914.5	1.1	293	263.2
13	61454.1	299.8	261.9	299.1	251.9	275.6	903.2	1.1	296.5	265.5
14	61874.9	307.4	259.1	318.2	215.6	276.1	944.3	1.1	310.1	277.6
15	62702.5	305.2	263.5	305.2	229.6	277.9	934.1	1.1	306.6	273
16	66714.4	315.7	270.9	325.2	256.4	286.7	956.2	1.1	325.1	289.2
17	68285.4	327.5	267.9	329.8	241.8	289.8	966.2	1.1	329.4	283.1
18	69674.1	339.1	264.1	335.4	234.8	292.2	979.1	1.1	329.6	273.3
19	71960.6	342.2	270	342	244.5	296.8	1002.9	1.1	338.9	291.1
20	74794.2	333.1	288.5	339	263	304.1	1016	1.1	330.2	291.3
21	79956.2	340.1	301.1	339	271.3	314.6	1033.3	1.1	344.6	306.8
22	80685.7	353.3	293.6	349.6	238.9	315.3	1065.2	1.1	354	297.3
23	84893.9	368.6	296.7	372.5	273.2	323	1107.6	1.1	367.2	316.6
24	85216.5	346.7	315.3	346.7	278.1	325.2	1082.8	1.1	351.7	314.4
25	103087	401.5	330.5	417.9	290.9	356.2	1224.2	1.2	411.6	345.8

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	40665.5	240.5	217	238.1	193.3	223.5	750.3	1.1	238.9	211
2	41142.4	254.1	207.9	251.1	191.7	224.3	753.2	1.1	250.9	218.4
3	45575.1	269.4	219	278.8	199.5	235.4	811.7	1.2	276.6	236.4
4	45785.5	258.5	228.2	274.3	213.5	237.6	834.1	1.2	276.4	231.2
5	46472.8	264.5	225.4	263.1	198.8	238.9	802.3	1.1	263.5	238.4
6	50554.8	267.7	242.3	275	209.2	249.5	838.9	1.1	268.7	253.6
7	52883.3	291.1	233.6	293.7	207.8	254.8	865.3	1.1	294.5	252.2
8	55478.4	291.8	244.2	286.7	216.5	261	863.1	1.1	291.4	253.1
9	55688.8	293.4	246.1	294.5	231	261	894.5	1.1	295.3	265.8
10	57933.2	300.7	249.1	319.4	235.8	266.4	967.9	1.3	315.1	260.8
11	59518.3	295.2	258.9	303.5	248.3	270.8	902.1	1.1	303.6	271.4
12	59897	293.8	261.9	298.2	227	271.7	908	1.1	288.4	271.8
13	62267.7	309.2	260.1	313	234.1	276.2	946.1	1.1	310	274.5
14	63712.5	321.8	256.1	328.4	223	277.9	965.2	1.2	326.4	274.9
15	64736.5	315.9	262.7	314.4	234.8	282.4	952.9	1.1	313.9	279
16	66714.4	331.7	258.1	327.6	239.3	285.8	971.1	1.1	325.2	273.1
17	67822.5	335.4	258.7	341.1	242.1	288.7	963.7	1.1	341.9	272.3
18	69197.2	329.5	269.8	335	243.1	291.8	987	1.1	332	284.9
19	70964.7	330.7	276.1	338	233.6	295.5	998.3	1.1	335.6	290
20	73882.4	328.9	288.6	321.7	263	301.6	1011.4	1.1	331.4	282.1
21	75902.3	335.5	291.1	345.6	258	305.8	1026.9	1.1	339	294
22	81302.9	372.8	280.8	376	260.4	315.4	1073.8	1.1	374.4	291.1
23	82312.8	348.7	304	357.8	256.7	318.3	1088	1.1	351.6	322.2
24	84543.2	354.4	306	357.9	273.8	323.1	1080.7	1.1	354.9	318
25	88064.1	371.1	305.9	389.7	274.3	330	1138.6	1.2	389.7	329.3

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	42895.8	258.2	215.6	263.9	201.9	230.1	773.8	1.1	265.4	231.5
2	51158	287.3	228.6	284.7	201.6	251.4	845.9	1.1	282.5	232.1
3	54720.9	289.5	243.4	305.7	222.3	259	893.4	1.2	298.9	258.5
4	55282	291.6	243.9	296	227.8	260.5	873.4	1.1	298.9	259.8
5	57021.4	283.7	259.1	285.8	222.5	265.3	888.6	1.1	286.8	259.2
6	58774.9	300.6	250.5	301.9	242.9	269.1	888.8	1.1	301.9	258.5
7	60682.6	283.7	274.4	295.6	242.9	273.9	910	1.1	286	283.6
8	63684.4	308.8	263.9	308.6	250.9	280.4	928.5	1.1	307.6	276.8
9	64876.8	323.6	257.3	322.6	225.3	282.6	949.1	1.1	314.5	265.5
10	67177.3	320.2	268.8	318.4	239	288.2	961.9	1.1	315.6	279.4
11	68594	323.3	273.6	334	234.6	290.3	977.9	1.1	324.3	282.5
12	68818.5	330	268.5	334.5	242.9	290.4	998.4	1.2	329.3	279.4
13	70263.3	312.3	288.4	316.6	253.5	294.2	974.3	1.1	318.3	308.8
14	70263.3	315.2	286	321.6	251.4	294.7	978.3	1.1	313.5	295.1
15	70978.7	342	265.3	348.5	262.3	295.7	997.7	1.1	349.7	282.3
16	71048.8	314.9	290.2	321.1	244.2	296.3	985.5	1.1	297.8	289.9
17	71357.4	316.7	289.6	323.3	262.8	296.7	995.3	1.1	313.5	282.2
18	72549.8	324.5	289.4	331.8	270.1	298.8	1012.7	1.1	330.7	309.7
19	74653.9	332.2	289.6	344	238.6	303.2	1032.9	1.1	335.1	297.8
20	74766.1	332.8	288.8	341.8	258	303.6	1018	1.1	338.9	299.8
21	75215	343.8	280.4	343.9	257.6	304.6	1013.9	1.1	346.7	276.1
22	83996.1	365.9	294.1	368.9	269.1	322.4	1069	1.1	364.4	300.5
23	86703.4	365.3	306.5	375.6	276.3	326.6	1118.6	1.1	372.3	334.9
24	99594.6	395.2	323	402.5	296.5	350.9	1170.8	1.1	403.7	334.6
25	99762.9	393.7	324.6	388.1	306.3	351.3	1166.2	1.1	388.2	337.3

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	61440.1	299.5	264.2	304.2	224	274.9	918.1	1.1	294	260.6
2	65872.7	317.8	268.5	323.2	244.6	284.2	962.3	1.1	318.3	281.2
3	69547.9	316.5	281.8	320	245.2	293.1	965.3	1.1	312	277.1
4	77978.4	351.8	283.9	350.4	266.2	309.8	1026.2	1.1	350.8	293.4
5	78315	339.9	296.5	347	261.5	310.7	1041.5	1.1	336.4	299.1
6	83533.2	363.1	297.2	389.5	263.9	319.8	1195.2	1.4	386.9	315
7	84318.8	361.8	300.5	362.7	271	321.9	1132.9	1.2	363	330.7
8	87727.4	359.2	313.4	367.2	280.7	329.5	1098.1	1.1	359.4	331
9	91627	368.5	322.4	381.7	283.4	337.1	1145	1.1	375.9	345.1
10	94895.4	373.8	329.6	381.2	280.2	341.8	1203.5	1.2	369.7	336.8
11	95975.5	390.8	317.4	394.5	256.3	343.4	1195.7	1.2	385.1	329
12	99384.2	423	310	423.2	279.7	350.5	1257.6	1.3	425.9	337.1
13	99510.5	402.6	318.7	398.4	289.9	350	1209.2	1.2	396	344.3
14	102302	395.3	334.3	406.6	287.2	355.3	1215	1.1	400	353.2
15	105500	384.9	353.7	393.3	326.7	361.2	1212.8	1.1	393.9	375.3
16	109063	416.3	336.5	418.8	317.2	366.9	1223.7	1.1	412.4	348.4
17	113370	405.4	360.5	418	325.9	374.5	1260.9	1.1	405.4	364
18	113889	419.6	351.5	419.4	323.3	374.6	1278.1	1.1	422.5	375.1
19	114351	425.4	345.1	427	319.2	376	1264.2	1.1	424.5	354
20	116708	421.2	357	428.6	327.6	380.2	1284.4	1.1	432.9	380.9
21	119696	451	341.8	453.4	301.9	384.1	1305.4	1.1	451.6	363.3
22	120902	431.5	361.6	438.1	303.6	386.2	1371.2	1.2	437.9	387
23	129122	448.1	372.9	463.2	304.4	398.6	1395.5	1.2	461.4	386.3
24	131661	442.4	383.2	456.2	348.6	404.2	1379.9	1.2	444.6	385.3
25	137623	447.3	398.6	444.6	349.7	415.4	1409.7	1.1	450	403.7

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	71357.4	325.7	282.1	328.4	253.3	296.5	995.5	1.1	323	288.9
2	71525.8	325.4	281.1	325.9	258.5	297.7	976.5	1.1	326.6	286.5
3	72844.3	356.4	263	357.8	247.3	298.3	1008.4	1.1	360	277.2
4	74191	322.2	296.4	334.7	271.2	303.7	1017.8	1.1	333	313
5	76351.2	349.9	282	350.4	263.1	305.7	1041.9	1.1	352.9	299.8
6	76421.3	350.9	279.9	342.1	247.9	306.5	1049.7	1.1	341	288.1
7	83841.8	365	296.1	374	251.4	321.1	1093.7	1.1	370.1	314.7
8	85665.4	355	316.1	361.3	288.4	329.5	1120.1	1.2	344.4	309
9	85763.6	384	288.5	381.4	246.7	323.2	1141.9	1.2	375.8	311.4
10	85988	369.9	302.8	373.2	269.9	324.4	1125.2	1.2	377.9	325.4
11	88793.5	380.8	299.7	380.5	286.4	330.2	1109.1	1.1	382.1	318.4
12	90953.7	383.4	305	391.7	274.3	334.7	1141.4	1.1	391.5	318
13	93352.4	389.4	307.4	384.7	280.9	339.1	1190.3	1.2	385.5	310.6
14	102765	385.7	342	382.8	318.2	356.8	1287.9	1.3	384.1	349.5
15	105234	398.6	341	410	311.7	360.3	1232.2	1.1	410.3	361
16	105893	399.5	338.8	393	300.5	362.5	1197.8	1.1	396.1	341.9
17	117017	444.3	338.2	437.9	305.9	379.5	1287	1.1	438.6	353.5
18	118896	436.3	351.8	439.2	313.6	382.6	1313.7	1.2	435.9	374.5
19	128926	470.3	351.5	466.6	332	398.2	1345.9	1.1	468.2	376.4
20	135042	448.1	387.8	459.3	365	409.3	1390.8	1.1	460.4	415.5
21	149967	486	398.6	477.8	324.1	430.2	1501.6	1.2	490.7	398
22	151622	476.5	410.4	484.1	362.9	433.4	1482	1.2	465.9	410.6
23	153123	493.2	398.8	498.8	371.9	435.7	1457.4	1.1	498.8	427.6
24	164528	501.4	429.1	518	308.3	444.7	1797.4	1.6	507	444.5
25	169297	517.3	425.4	520.2	384.2	458.3	1565.5	1.2	520.7	448.6

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	46416.7	257.1	232.9	263.7	196.4	238.6	902.5	1.4	262.1	251.5
2	56628.7	305.2	238	308.2	217.9	263.2	911.4	1.2	308.3	253.3
3	60668.6	311.7	249.1	314.4	235.1	273.5	909.4	1.1	315.1	257.2
4	63067.2	330.4	245.5	326	225.5	277.3	934.2	1.1	326.2	258.5
5	63277.6	303.7	267.5	310.9	224.4	279.4	935.3	1.1	298	266.8
6	64834.7	332.9	255.7	334.4	210.9	283.4	1081.7	1.4	334.3	287.3
7	73124.9	331.9	281.7	335	261.9	300.8	1031.9	1.2	336.1	290.7
8	74064.7	335.3	285.3	340.1	241	302.3	1113.9	1.3	325.4	308.1
9	81302.9	363.6	288	363.6	264.4	315.9	1083.3	1.1	365.3	307.3
10	82873.9	354.1	300.9	354.5	264.8	319.4	1115.7	1.2	353.6	309.3
11	92777.3	366.9	328.9	380.1	286.4	340.7	1143.3	1.1	361.6	328.6
12	94558.8	372.5	325.9	372.8	295	341.7	1142.2	1.1	365.2	318.6
13	94923.5	379.9	322.6	374.6	300.8	341.6	1203.3	1.2	374.1	361.5
14	97518.6	409.9	307.1	407	238.6	344.8	1238.1	1.3	408.6	327.5
15	97953.4	378.2	331.9	385.3	308.3	349.1	1154.4	1.1	384.3	346.6
16	99047.5	404.3	315.4	399.9	278.4	348.4	1285.1	1.3	393.4	328.8
17	101348	409.2	318.5	404.5	288.3	352.8	1200.6	1.1	406.5	335.5
18	105697	401.1	340.5	404.2	310.3	361.4	1265	1.2	422.4	354.1
19	106131	382.6	356	393.7	312.5	363.2	1242.9	1.2	395	374.1
20	107422	416.1	337.4	425.2	285.7	361.2	1297.3	1.2	428.2	369.7
21	110985	408	350.4	434.6	322.3	371.2	1326.7	1.3	430.1	361.1
22	112921	414.7	349.4	415.5	305.7	374.4	1258.8	1.1	404.3	337.3
23	122263	447.1	352.7	435.6	297.4	387.8	1344	1.2	441.6	349.8
24	129249	457.7	364.7	458.8	314.4	400.3	1371.9	1.2	460.3	379.2
25	138745	465	383.1	474.8	361.6	414.7	1406.6	1.1	478.5	407.1

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	46949.7	254.4	236.4	261.6	211.5	240.2	801.6	1.1	251	229.8
2	50975.6	274.1	238.9	276.2	203.1	250.5	889.7	1.2	283.5	244.8
3	61215.6	312.5	251.8	306.8	218.8	273.6	936.1	1.1	309.4	256.6
4	65774.5	315.2	269	324.7	245.2	284.2	1031.2	1.3	337.8	287.8
5	66181.3	305	278.1	311.5	251.8	286.1	1018.5	1.2	311.2	276
6	66251.5	320.9	267.9	345.9	243	285.4	1207.2	1.8	338.5	279.4
7	67373.7	320.6	271.4	328	243.4	287.5	975	1.1	330.6	286.1
8	76954.4	323.8	305.3	344.8	277.9	308.5	1044.6	1.1	347	319.7
9	77305.1	347.9	284.9	351.1	264.8	309.1	1049.3	1.1	346.4	293.5
10	83364.9	343	311.9	349	270.1	321.4	1116.9	1.2	351.5	342.6
11	84360.8	359.7	302.7	389.3	269.1	322.5	1117.2	1.2	381.1	326.2
12	92875.5	396.1	304.2	392	256.6	335.6	1195	1.2	396.3	325.7
13	93534.8	385.8	315.1	396.7	266.4	338.4	1192.6	1.2	396.9	336.8
14	97546.6	394.7	317.7	392	280.2	346.4	1192.7	1.2	384.2	317.5
15	105276	401.3	336	405.1	319.9	361.4	1201.1	1.1	406.2	351.2
16	113440	461.2	328.4	448.8	177.7	361.9	1672.5	2	449.6	356.2
17	116259	424.6	351.6	426.5	331.3	378.9	1319.1	1.2	428.6	371.1
18	124690	432.6	370.2	477.4	324.2	393.4	1465	1.4	479.7	396.4
19	125503	459.9	354.8	464.6	326.2	392.1	1381.1	1.2	468.9	389
20	127958	423.7	388.1	433.5	359.6	398.6	1376.3	1.2	428.9	385.3
21	131675	456.7	372.8	455.4	331.8	403.5	1420.7	1.2	463.6	387.9
22	135056	451.5	384	459.4	345.1	409.8	1412.7	1.2	452.3	401.4
23	142434	463	394.4	486.3	373.5	420.7	1533.6	1.3	488.7	408.7
24	152113	514.3	388.7	509.8	323.2	436.6	1552.9	1.3	507.8	405.6
25	153320	488.3	404.4	505.1	356.6	435.9	1550.7	1.2	499	407.3

G. siphonifera GLOW 3 BoxTop Hole 1

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	85412.9	374.6	293	374.6	255.3	323.9	1109	1.1	375.9	306.1
2	88765.5	389.9	295.6	433.5	265.1	329.5	1297	1.5	428.5	313.1
3	99594.6	416.7	307.1	413.4	268.1	349.1	1202.6	1.2	413.1	325.5
4	107871	430	323.7	434.5	260.8	362.8	1302.2	1.3	434.4	345.2
5	114871	440.8	336.9	444.5	306.2	375.4	1313.5	1.2	444.3	357.5
6	118097	440.1	347.5	439.8	291.7	380.3	1343.7	1.2	441.4	368.2
7	121099	457.3	341.6	455.5	277.7	384.5	1372.1	1.2	453.5	360.4
8	121534	452.6	345.7	453.9	301.5	386.4	1371.6	1.2	455.4	367.3
9	121828	429.3	369.6	429.2	298.5	388.3	1376.6	1.2	431.3	375.4
10	131731	485.7	353.7	494.4	330.9	399.7	1464.1	1.3	495.8	393.1
11	134046	478.4	363	477.8	308.2	404.5	1437.5	1.2	480.6	392.5
12	136557	515.1	348.8	585.2	293	407.2	1878.2	2.1	587.3	373.5
13	141130	460.8	402.8	479.5	359.2	422.9	1452.3	1.2	463.5	411.9
14	141410	515	354.3	509.7	305.4	414.8	1459.5	1.2	510.2	372.3
15	146124	493	380.7	488.3	316.6	424.7	1465.1	1.2	494.1	394
16	147709	507.4	374.4	506.2	330	426	1471.8	1.2	505.1	393.5
17	150472	491.2	397.5	517.3	366.5	430.6	1575.9	1.3	521.7	430.1
18	150823	474.5	410.4	486.4	336.9	431.9	1542.6	1.3	482.9	425.3
19	169942	559.8	390.4	543.1	318.4	455.4	1612.7	1.2	543.7	394.2
20	174515	547.4	411.6	550.9	341.2	463.1	1640.8	1.2	543.2	427
21	176886	512.3	447.1	527	420.5	468.3	1616.9	1.2	534.4	478.5
22	185863	550.6	439.1	564.3	319.8	476.8	1795.8	1.4	544.1	455.1
23	189356	537.7	460.5	579.4	412.6	486.8	1749.7	1.3	576.8	495.3
24	237274	609.2	505	626	462.2	541.5	1902.4	1.2	634.3	542.5
25	272525	682.2	520.4	707.9	435.8	577.1	2164	1.4	712.5	571.9

G. siphonifera GLOW 3 BoxTop Hole 2

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	61538.3	309.3	256.4	316.5	237.4	274.9	935.3	1.1	315.6	272.7
2	71301.3	350.8	262.9	359.1	244.6	294.4	1041.8	1.2	352.9	276.6
3	73545.7	346	274	350.4	254.7	299.9	1043.2	1.2	351.1	293.3
4	81920.1	369.4	286.8	372.5	261.9	315.8	1116.8	1.2	373	312.8
5	87727.4	359.7	313.9	364.9	235.7	328.5	1158.2	1.2	360.9	320.2
6	89508.9	387.1	297.1	389.5	277.5	331.4	1135.8	1.1	391.5	314.8
7	96634.8	398.1	312.1	399.5	272.7	345.1	1197.8	1.2	399.3	328.9
8	96789.1	398	313.1	392.1	251.6	345	1220	1.2	392.3	320.6
9	110859	435.7	326.9	434.6	281.6	368.8	1268.7	1.2	434.4	345.1
10	111167	445.4	321.7	449.6	286.5	368.3	1287	1.2	453.7	340.5
11	112346	433.3	335.8	434.9	306.9	371.7	1304	1.2	439.2	353.7
12	116357	427.7	353	439.2	320	378.1	1350.1	1.2	438.8	392.7
13	118279	421	365.7	435.8	251.2	380.6	1453.2	1.4	400	362.7
14	118995	454	338.3	448	260.8	381.7	1337.3	1.2	449.6	357.7
15	123217	455.7	349.1	461.8	319	388.5	1360.2	1.2	461.2	377.4
16	134635	449.2	384.9	456.9	357.4	408.7	1439.1	1.2	457.8	413.6
17	143669	492.1	377.7	496.8	329.3	419.6	1514.2	1.3	492.9	413.4
18	150276	495.7	390.4	505.4	330.9	430.3	1521.9	1.2	503.9	412.2
19	153488	493.9	402.9	503.7	342.5	433.9	1560.7	1.3	504.7	428.5
20	159057	500.4	416.2	535.6	297.8	437.5	1810.4	1.6	531.3	450.8
21	160067	507.2	407.2	511	367.9	444.4	1527.6	1.2	508.9	430.7
22	193536	536	468.3	553.6	379	489.2	1756.3	1.3	542.7	484.9
23	211379	600.1	456.4	597	387.2	509.4	1819.8	1.2	597.4	471.3
24	282512	652.1	561.5	682.5	424.6	590.2	2155.8	1.3	667.6	586.6
25	371235	793.8	604.3	778.2	501.2	676.8	2485.3	1.3	783.8	632.8

G. siphonifera GLOW 3 BoxTop Hole 3

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	39543.3	261.4	196.2	258.3	171.8	219	771.7	1.2	259.7	214.2
2	55941.3	310.8	233.9	320.3	199.4	259.7	939.6	1.3	320.2	257
3	68608.1	357.9	248.8	388.4	225.3	287.7	1190.2	1.6	388.2	262.4
4	77389.2	360.6	277.1	367.7	235.8	308.3	1207.5	1.5	349.8	278.6
5	83701.6	371.8	289.3	372	259.3	320.9	1107.4	1.2	374.6	298.3
6	87124.2	392.1	286.2	388.9	233.3	325.1	1163	1.2	387.2	297
7	91037.9	405	291.1	407.9	270.5	332.3	1194.6	1.2	407.9	316.8
8	91893.6	400.1	296.7	398.8	269.1	334.5	1165.3	1.2	398.1	313.6
9	93128	381.5	315.3	385.3	293.8	338.6	1161.3	1.2	386.3	334.9
10	115614	444.4	339	450.2	251.2	374.4	1482.5	1.5	452.3	362.4
11	123736	458.5	349.4	471	297.8	389.1	1391.9	1.2	472.4	375.7
12	132208	463.2	369.9	470.5	310.8	403.2	1475.1	1.3	466.8	387.6
13	138633	498.9	357.8	498.1	297	411.9	1493.5	1.3	499.3	371.1
14	143192	493.6	373.1	525.2	321.1	420	1514.9	1.3	525	391.1
15	143346	508.6	366.8	511.9	330.8	417	1533.6	1.3	510.4	406.5
16	150795	496.7	396.2	524	342.5	432.3	1586.7	1.3	523	418.5
17	159604	487.8	423.1	499.8	385.6	444.7	1530.2	1.2	497.6	434.9
18	161946	489.5	429.3	507.6	320.2	446.9	1747.7	1.5	510.4	472.3
19	164654	508.3	418.4	512.5	362.7	451.2	1636	1.3	510	437.5
20	179859	573.8	415.9	572.3	340.9	475.9	1900.4	1.6	570.6	445.9
21	188164	553.8	436.7	554.2	391.7	482.9	1667.3	1.2	548.5	464.5
22	251946	649	498.5	676.8	450.6	559.2	2079.3	1.4	681.5	520.7
23	344177	712	632.6	742.9	537.8	654.5	2390.7	1.3	748.8	671.2
24	394942	810.4	627.2	803.6	523	699.6	2609.4	1.4	804.2	644.8
25	409614	767.9	691	789.3	538.3	713.8	2593.1	1.3	758.5	720.8

G. siphonifera GLOW 3 BoxTop Hole 4

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	39136.5	259.8	196.3	256	161.4	217.4	795	1.3	256.5	212.1
2	55113.7	310	230.8	315.2	203.1	258.6	920.7	1.2	316.4	255.9
3	65844.7	336.1	252	337.3	235.8	283.4	967.8	1.1	337.6	269.2
4	73167	360	262.8	358.5	218.1	298.1	1059.9	1.2	357.9	278.6
5	80840	360.9	287.7	361.5	255.7	315.6	1082.7	1.2	359.3	314.5
6	85833.7	390.1	282.8	386.4	246.3	322.9	1124.1	1.2	387.7	296.1
7	88737.4	398.9	288.3	401	267.6	328.3	1166.1	1.2	402.8	315.4
8	90799.4	407.5	287.9	421.5	250.4	332.4	1223.8	1.3	421.5	306.8
9	93001.7	388.6	308.7	405.1	288.1	337.8	1199.7	1.2	402.3	332.2
10	110045	431.3	331.3	418.7	259.4	366	1305.8	1.2	420.8	351.2
11	118433	445.2	344.3	456.2	324.7	381.1	1333.1	1.2	457.6	374.9
12	130118	457.5	368.7	465	319.6	399.4	1410.9	1.2	463.8	385
13	135154	495	355.1	498.9	320.7	404.6	1477.6	1.3	498.6	394.7
14	136164	494.2	354.8	491	286.4	408.2	1465.4	1.3	493.2	372.9
15	141018	484.2	374.5	477.4	323.9	417.4	1442.7	1.2	476.9	386.9
16	146657	492.1	388.3	504.6	349	426.5	1557.2	1.3	504	419
17	156462	475.3	424.9	490.7	400.5	440.4	1542.2	1.2	490.8	462.9
18	159730	488.5	423.3	509.5	327.6	444.3	1619.6	1.3	489.4	444.6
19	162073	501.5	416.9	511.3	390	447.6	1579.2	1.2	510.9	443.7
20	179649	566.9	413.3	569.9	312.7	470.6	1792.7	1.4	568.7	460.6
21	179649	545.1	422.6	534.8	383.9	471.2	1603.7	1.1	527.7	436.5
22	247163	654.8	484.6	663.4	440.6	553.3	2014.7	1.3	662.5	507.2
23	339912	719.3	614.7	749	554.3	649.5	2320.6	1.3	757.6	671.7
24	391393	809.7	620.2	808.2	550.2	696.9	2407	1.2	808	631.3
25	404537	783.8	667.1	796	534.2	708.6	2506.5	1.2	789.5	706.6

G. ruber 871A 1H 1 124-126 Hole 1

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	34577.6	229.9	192.7	228.3	161.4	205.7	683.4	1.1	227.4	197.7
2	36317	233.1	199.3	233	179.8	210.7	695.7	1.1	234.6	204.8
3	37102.5	242.9	195.7	235.7	165.2	212.6	715.2	1.1	230.9	190.6
4	43190.4	244.6	227.6	244.6	214.5	229.9	768.6	1.1	247.1	234.2
5	44551.1	258.2	221	253.6	199.1	234.1	777.1	1.1	247.3	224.7
6	49390.5	271.9	233.4	268.5	218.2	246.1	822.7	1.1	267	239.4
7	50372.4	273.8	235.9	271.5	196.5	248.8	841.3	1.1	260.9	239.3
8	51817.3	287.4	231	284.5	198.5	251.7	839.6	1.1	282.5	226.4
9	51845.3	275.4	241	275	210.9	252.6	839.7	1.1	273.3	240.2
10	52069.8	291.2	230.1	300.8	198.5	252.3	897.6	1.2	285.5	232.4
11	54215.9	306	227.5	298.5	181.2	256.8	876	1.1	297	226.3
12	55450.4	291.8	244.3	286.1	214.5	261.1	881	1.1	283.2	246.2
13	56418.2	308.6	235.5	307.1	202.3	262.1	941.3	1.2	309.4	237.8
14	60528.3	306.7	253.1	304.6	222.1	272.6	936.9	1.2	296.6	258.9
15	60921	319.5	244.9	319	206.4	273.1	929.1	1.1	317.3	242.6
16	61510.2	314.2	251	304.4	221.8	274.4	921.9	1.1	307.5	249
17	62281.7	320.1	249.8	316.1	221.8	275.9	929	1.1	316.5	249.8
18	65620.2	328.2	257.1	321.3	209.8	283.3	970.5	1.1	311.3	251.1
19	81429.1	349	303.8	354.1	277.6	316.6	1220.7	1.5	357.6	344.1
20	82733.7	363.2	293.5	361.6	243.9	319	1092.9	1.1	359.4	294.8
21	82958.1	377	283.7	374	240.4	318.5	1097.4	1.2	370.2	285.5
22	85553.2	362	303.8	355.9	261.9	324.6	1116.5	1.2	346.2	300.7
23	85791.6	355.5	310.3	358.5	293.6	325.5	1082.3	1.1	348.7	316
24	92833.4	369.3	323.5	368.9	302.5	338.6	1196.1	1.2	370.8	337.2
25	109751	426.9	330.1	421.9	280.9	367.4	1243.7	1.1	418.9	336.1

G. ruber 871A 1H 1 124-126 Hole 2

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	29625.9	218.3	174.6	208.7	147.3	189.1	641.3	1.1	203.4	172.8
2	30299.2	210.7	184	210	171.8	192.1	637.4	1.1	209.7	179.8
3	38224.7	246.4	198.8	240	165.9	215.8	724.3	1.1	235.9	190.3
4	43288.6	258.7	214.2	254.9	187.3	230.2	755.6	1	250.9	208.1
5	47062	271.5	223.4	265.3	202.3	239.7	816.7	1.1	261.5	226.5
6	47090	282.2	214	276.2	187.3	239.4	820.9	1.1	279.1	209
7	49264.3	277.7	229.3	272	207.7	245	867.5	1.2	272.2	239.2
8	49657	290.8	219	283.5	180	247.8	838.9	1.1	283.9	220.5
9	53065.7	302.7	226	311.1	202.7	253.9	906.6	1.2	315.1	234.8
10	55324.1	292.2	244.7	289.1	221.5	260	883.9	1.1	289.9	254.6
11	55815.1	302.1	237.7	311.6	210.6	261.6	934.3	1.2	308.2	236.5
12	55983.4	316.3	233.8	308.3	199.4	262.6	964.6	1.3	300.8	241.6
13	58466.2	314.5	238.6	330.3	200.3	267	1032.2	1.5	331.1	246.2
14	59069.4	313.2	241.7	306.3	213.5	269	904	1.1	308.7	241.6
15	62786.7	314.3	255.8	318.4	239.3	278	950.2	1.1	315.3	259.8
16	68215.3	330.8	268	325.8	239.7	289.4	993.5	1.2	323.2	277.2
17	70207.2	347	260.2	347.3	209.7	292.5	1068.1	1.3	344.9	265.4
18	71161.1	343.6	266.6	339.4	224.8	295.3	1021.7	1.2	339	276.9
19	73503.6	349.8	269.9	351.1	247.9	299.8	1025.2	1.1	352.1	275.8
20	75229	345	280.9	341.6	256.7	303.9	1035.7	1.1	338.2	293.5
21	76968.4	347.3	285.8	343.4	253.9	307.5	1116.6	1.3	337.3	295.3
22	79072.5	350.6	292.9	344.6	261.8	311.8	1097.6	1.2	336.6	308.7
23	86535.1	376.1	299.3	373.1	276.3	326.5	1134.1	1.2	374.1	309.4
24	98809.1	393.5	321.3	388.6	286.5	349.5	1158.2	1.1	387.2	315.2
25	101951	409.3	321.6	407.5	274.7	353.2	1217.3	1.2	404.6	333.7

G. ruber 871A 1H 1 124-126 Hole 3

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	28770.2	209.4	176.5	203.9	158.9	188.1	620.9	1.1	201.7	178
2	31140.9	223.1	179.2	218.4	161.1	194.3	646.5	1.1	222.4	181.5
3	32375.3	216	193.7	219.8	184.4	198.6	663.3	1.1	221	199.9
4	33525.5	227.1	189.5	233.6	165.5	202.1	705.6	1.2	229.1	187.3
5	34970.3	229.7	195	228.1	172.3	206.4	682.9	1.1	223.9	196.3
6	39010.2	252.4	198.3	243.9	168.5	218	730.7	1.1	240.2	194.9
7	41563.2	259.4	205.9	253.2	186.4	224.7	752.2	1.1	250.9	209.7
8	41899.9	256.2	209.9	251.1	176.1	226	765	1.1	245	201.8
9	42685.4	272.2	201.1	264.9	173.2	227.2	770.4	1.1	266.6	204.3
10	42867.8	259.2	213.2	269.7	194	228.7	815.7	1.2	276.8	225.9
11	43695.4	260.7	215.3	258.5	180.1	231	822	1.2	256.3	233.1
12	43975.9	268.8	210.9	261.9	183.6	231	785.1	1.1	258.3	214.2
13	46416.7	262.1	227.1	257.3	203.1	238.2	789.2	1.1	251.4	224.9
14	48997.7	279.6	224.8	277.5	193.5	244.6	823.7	1.1	272.7	221.1
15	50821.3	285.6	229.7	282.1	199.1	248.6	856.2	1.1	280.9	232.1
16	51873.4	282	236.6	278.4	210.3	252.1	852.5	1.1	281.7	244.4
17	52448.5	292.6	230.2	289.9	212.9	253.2	869.9	1.1	300.5	234.6
18	57105.6	311	235.8	307.9	195.5	263.4	927.7	1.2	305	240
19	60051.3	304	253.6	301.3	218.4	271.8	908.7	1.1	291.2	249.1
20	62800.7	314.7	258.6	308.2	235.8	276.6	972.9	1.2	307	262.4
21	72774.2	339.5	276.3	335.2	240.9	298.4	1021.5	1.1	326.9	276.5
22	77571.6	353.9	281.5	349.8	232.2	308.3	1043	1.1	348.1	283.3
23	94278.2	397.2	306.6	391.6	274	339.7	1187.1	1.2	390.7	318
24	106707	423	325.7	415.3	251.9	362.1	1289.9	1.2	412.1	319.4
25	116217	433.6	347.2	431.2	317.8	377.7	1319.8	1.2	430.4	372.1

G. ruber 871A 1H 1 124-126 Hole 4

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	28195.1	206.3	175.6	204.7	160.1	185.5	608.6	1	202.6	178.9
2	29345.3	219.7	171.6	234.1	146.1	187.4	697	1.3	234.2	173.1
3	34970.3	228.1	197.9	227.8	187.7	205.9	687.6	1.1	228.5	208.5
4	35433.2	231.7	196.2	226.3	171.8	208.2	697.5	1.1	222	194.7
5	35755.9	216.4	213.1	218.1	197.8	208.6	693.6	1.1	217.1	217.1
6	36162.7	232.9	199.2	228.5	183.5	210.9	700.5	1.1	228.5	203.2
7	36822	250.5	188.4	244.6	169.4	211.1	713.2	1.1	245.1	189.8
8	37621.5	240	201	236.5	174.6	214.6	712.6	1.1	237.5	203.5
9	41086.3	260.9	201.6	258.5	180	223.9	756.7	1.1	263.3	204
10	42026.1	256.2	210.5	247.6	183.5	226.8	751.6	1.1	242.8	208.5
11	42222.5	253.7	213.1	251.2	189.9	227.8	748.5	1.1	248.4	208.8
12	43176.4	264	210.8	261.8	194.8	229.2	771.4	1.1	264.3	217.8
13	43737.5	247	228.1	248.6	213.5	231.5	805	1.2	251	246
14	45392.7	268.3	216.6	274.7	194	235.7	821.2	1.2	274.2	215.5
15	46486.8	259.7	229.8	278.7	212.2	239.3	816.5	1.1	259.5	232.1
16	49643	284.6	225.7	275.4	202.8	245	838.4	1.1	274.1	234.3
17	56348.1	295.9	243.7	289.9	209.7	262.9	887.4	1.1	290.8	250.6
18	63558.2	315.9	258.4	308.8	218.8	279.4	939.9	1.1	299.5	251.3
19	67542	326.2	265.6	323.9	214	288.1	976.9	1.1	321.1	261.3
20	68047	326.6	269.1	323.5	244.6	288.8	996.3	1.2	321.5	280.4
21	75804.1	346.2	281.3	354.5	243.4	305.6	1043.1	1.1	346.2	273.9
22	80952.2	350.8	298.3	349.2	273.7	315.5	1076.2	1.1	347.5	314.2
23	86885.8	372.7	300.9	365.6	251.9	326.2	1125.7	1.2	357.7	305.2
24	90687.2	382.9	303.3	377	252.3	334.6	1136.3	1.1	375.4	295.1
25	92314.4	371.4	320.5	369.7	288.4	337.7	1140.5	1.1	356.6	330

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	63432	311.4	261.1	313.1	243.6	279.7	912.8	1	308.9	270
2	68018.9	313.2	276.9	313.6	268	290.8	930.4	1	308.8	276
3	69393.6	329	271.3	326.6	246.4	291.9	971.5	1.1	324.7	271.5
4	76281.1	342.3	285.4	340.8	268.5	307.4	999.7	1	337.4	285.5
5	76393.3	339	289.1	340.8	266.2	307.2	1006.4	1.1	330.7	290.2
6	79521.4	339.3	299.9	346.6	274.7	313.9	1027	1.1	339.1	312
7	86843.7	375.1	297.6	372.7	283.1	326.9	1085.7	1.1	378.8	306.1
8	86998	373	300.4	374.6	277.3	327	1111.3	1.1	386	296.1
9	90827.5	380.5	308.4	378.4	277.3	333.7	1131.3	1.1	377.9	313.8
10	91683.2	379.3	310.5	378.3	288.8	336.1	1114.1	1.1	379	316
11	93815.3	381	317	376	279.1	340.2	1136.5	1.1	377.6	318.3
12	93899.5	379.5	317.8	380.7	291.4	340.5	1137.9	1.1	376	316
13	98668.8	394.4	322.2	397.9	291.3	349.1	1162.4	1.1	395	331.4
14	99524.5	394.8	324.7	395.8	290.1	349.9	1179.5	1.1	398.2	325.3
15	103354	398.1	333.3	395.8	313.3	357.7	1187	1.1	394.1	341.8
16	106286	414.1	328.9	406.4	299.3	362.5	1193.6	1.1	408.3	327.1
17	108895	411.9	338.8	412.8	324.7	367.4	1223.4	1.1	414.4	340.9
18	118602	428.6	355.1	433.9	333.7	383.4	1267	1.1	426.7	369
19	119962	429.1	358.7	425.3	329.9	385.7	1277.7	1.1	420.6	364.3
20	123385	436.7	362.6	438.9	337.6	390.9	1294.9	1.1	428.2	368
21	134509	454.5	379.9	456.9	354.5	408.5	1355.6	1.1	450.3	385.7
22	136669	464.5	378	472.8	356.9	411.3	1366.3	1.1	470	384.5
23	141747	476.9	383.1	470.7	336.3	418.9	1405	1.1	465.5	385.1
24	153039	475.4	413.8	481.9	389.4	437.4	1599	1.3	478.5	415.6
25	157191	474.9	424.1	474.4	384.4	442.7	1469.3	1.1	466.7	425

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	51831.3	276.3	241.5	282.1	220.6	253.6	837.2	1.1	277.6	245.3
2	56726.8	296.4	246	291.7	229.3	263.9	874.2	1.1	299.4	247.8
3	69576	333.9	268.3	333.4	253.2	292.5	989.2	1.1	335.1	274.2
4	73475.6	338.4	277.9	333.3	261.5	301.2	981.4	1	331.7	280.9
5	73615.8	328.3	287.3	335	270.1	301.9	987	1.1	327	292.7
6	75130.8	340.2	284.4	335.9	251	303.6	1029.8	1.1	338.6	288.7
7	77220.9	351.2	282.2	351.2	261.8	308.5	1015.6	1.1	350.6	288.9
8	79156.7	363	280.8	352.1	259.5	311.7	1042.1	1.1	353.7	282.3
9	79773.9	359.4	286.3	357.8	262.3	312.8	1049.1	1.1	363.4	292.9
10	79787.9	355.7	287.7	354.7	267.5	313.9	1045.3	1.1	358.5	293
11	82284.8	356.1	297	359.9	278.7	318.5	1053.7	1.1	354.7	299.4
12	85581.2	367.2	299.8	370.3	273	324.7	1082.8	1.1	363.6	309.9
13	95330.3	386.7	316.1	387.3	297.8	343.5	1129.3	1.1	386.2	323.8
14	98318.1	389	325.4	396	308.8	348.6	1160.1	1.1	389.6	329.3
15	101054	398.5	325.9	399.3	306.8	353.3	1187.7	1.1	395.8	328.4
16	105570	413	328.5	424.1	309.2	360.7	1219.7	1.1	414.9	337.9
17	106482	407.2	335.4	405.5	315.7	363	1204.4	1.1	411.4	338.1
18	110466	409.2	345.5	407.1	327	370.3	1207	1	404.6	345.8
19	116147	426.3	350.5	432.9	334.5	378.8	1263.2	1.1	428.2	363.6
20	118616	424.5	358.4	426.5	327.4	383.7	1270.6	1.1	409.6	363.7
21	129249	448	370.8	486.8	357.5	400	1353.4	1.1	467.1	381.1
22	129712	441.9	378.6	449.2	344.3	401.2	1352.3	1.1	447.2	398.2
23	129936	453	367.4	455.1	338.1	401.4	1319.7	1.1	437.4	371.7
24	131563	454	372.2	465	349.7	403.9	1339	1.1	456.2	377.9
25	146292	475.9	394.5	481.1	374	426.1	1420	1.1	479.4	395.2

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	43793.6	265.6	212.2	264.9	194.3	231.4	777.9	1.1	263.1	215.2
2	47777.4	267.8	229.3	267.4	204.4	244.2	799.6	1.1	267.3	230.7
3	56011.5	297	242.2	297	223.3	261.9	873.3	1.1	291.3	246.8
4	58410.1	299.9	249.8	294.9	231.2	268.3	890.4	1.1	291.8	254.9
5	59083.5	303.4	250	309.9	226.5	269.4	890.3	1.1	301.1	255.8
6	75874.3	355.2	274.9	367	254.2	304.9	1044.4	1.1	368.7	283.1
7	77627.7	348.8	285.9	348.5	265.3	309.3	1026.1	1.1	341.7	289.7
8	82088.4	346.7	304.3	355.5	277.3	318.5	1064.6	1.1	349.6	303.5
9	82775.7	353.5	300.3	361.1	275.3	320	1065.9	1.1	355	311.7
10	83491.1	357.8	299.9	364.3	275.9	320.7	1076.8	1.1	356.5	308
11	89410.7	364.4	313.7	373.8	298.1	332.9	1110.3	1.1	379.2	318.6
12	90448.7	357.8	323.5	365.7	299.6	335	1131.3	1.1	364.4	328.3
13	91178.2	372.6	313.9	377.8	293	335.9	1125.3	1.1	376.1	312.9
14	100072	388.3	330.9	383.5	302.3	352.2	1151.9	1.1	391	331.2
15	100086	387.7	331.2	387.5	303.9	351.7	1165	1.1	380	338.5
16	102989	400	330.6	399.5	308.5	357.1	1178.3	1.1	400.2	338.3
17	103536	406.8	326.9	402.5	300.2	357.5	1191.8	1.1	400.6	332.6
18	109049	409	341.7	417.1	329.3	367.6	1205.9	1.1	406.7	349.7
19	110522	406	348.3	407.1	333.3	371	1216.9	1.1	404.2	346.5
20	112710	438.3	334.3	510	306.7	372.5	1458.1	1.5	514.7	344.4
21	113019	412.7	351.3	412.1	329.3	374.3	1241.6	1.1	410.8	360.8
22	117466	421.8	357.1	417.8	333.4	381.9	1262.3	1.1	413.2	366.8
23	117886	429.2	352.3	426	323.6	382.9	1257.8	1.1	420.5	355.1
24	119836	433.1	355.4	427	319.9	384.9	1280.7	1.1	422.1	358.9
25	125419	441.4	364.5	442.3	338.4	394.5	1314.4	1.1	436.8	367

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	52210	283.6	236.5	282	214.6	253.3	837.7	1.1	280.9	234.4
2	54580.7	294.5	238.1	297.5	222.8	258.7	872.3	1.1	294	251.6
3	65606.2	316.6	266.5	317.5	247.9	284.1	943.1	1.1	316.3	271.4
4	65620.2	299.2	280.4	305.6	255.6	285.3	941.1	1.1	297	278
5	65830.6	320.4	263	319	248.3	284.9	936.6	1.1	312.3	264.2
6	77417.3	336	294.5	338.4	273.4	309.6	1021.4	1.1	331.3	305.1
7	78062.5	345.6	290.5	344.5	263.8	310.5	1035.8	1.1	336.5	289.4
8	86829.7	375.9	297.3	374.3	266	326.5	1116.7	1.1	367.2	299
9	90603	370.5	315	401.8	284.5	334.7	1183.2	1.2	396.8	326.7
10	92580.9	379.3	313.8	388.1	297	337.8	1127.8	1.1	383	320.9
11	93703.1	376.5	319.6	383.2	300.1	340.9	1129.1	1.1	376.1	324
12	97139.8	389.2	321	393.3	298.3	346.3	1154	1.1	396.5	320.7
13	101152	382.5	339.4	392.3	303.5	354.5	1183.5	1.1	373.3	349.4
14	102835	400.4	330.2	425.6	317.8	357	1225.1	1.2	428.9	335.8
15	102947	396.5	333	399.1	315.8	357	1189.7	1.1	408.3	336.3
16	103368	395.1	334.9	396.1	317	358.3	1184.5	1.1	397.6	334.6
17	104252	395.7	338.2	409.1	323.1	359.3	1214.7	1.1	402.5	349.2
18	104378	384.4	346.7	386.2	323.8	360.6	1169.8	1	383.3	338.5
19	108488	412.3	340	415.7	303.5	365.3	1269.2	1.2	407.6	361.6
20	111322	424.2	337.6	417.8	314.1	370.4	1244.5	1.1	422.1	338.1
21	114842	436.6	339	438.5	311.2	375.7	1265.9	1.1	441.8	346.9
22	125728	442.2	365.2	448.6	345.7	394.5	1309.2	1.1	445.3	369.5
23	126471	430.1	376.2	427	353.2	396.5	1315.3	1.1	423	371.5
24	134298	454.8	379.5	463.6	345.2	408	1360.3	1.1	452.7	386.8
25	138282	455.8	389.2	461	367.1	414.6	1392.7	1.1	460.8	386.8

G. rubescens GLOW 3 BoxTop Hole 1

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	13466.3	137.5	125.6	139.8	111.2	127.1	420.7	1	139.5	128.9
2	16356	152.3	138.8	154.3	129.8	141.3	478.4	1.1	154.4	148
3	16468.2	149.8	141.9	150.6	134.1	141.4	467.1	1.1	159	141
4	17211.6	157.4	140.5	156.9	132.8	144.6	476.4	1	161.5	138.3
5	17562.3	167.8	134.1	162.8	128	146.8	480.2	1	165.3	138
6	17590.4	158.7	142.1	157.3	130.4	145.8	473.9	1	158	144
7	18207.6	169.6	137.8	167.5	127.8	149.7	487.4	1	173.5	137.6
8	19133.4	160.7	153.7	160	140.8	152.8	502.6	1.1	164.2	150.8
9	20339.7	173.5	152.8	173.3	144.7	158.8	527.4	1.1	173.8	160.5
10	20452	165.2	160.2	171.1	143.4	158.8	524.8	1.1	171.8	168.8
11	20788.6	176.5	151.4	179	135.7	159.3	547.9	1.1	178.6	159.9
12	20830.7	169.3	158.1	176.7	138.1	159.8	535.4	1.1	170.7	162.3
13	22359.7	185	156.2	186.6	145.7	164.1	557.8	1.1	187.2	171
14	23355.6	188.5	161.4	188.1	146.1	169.5	581.2	1.2	186.6	169.6
15	25263.4	186.7	175.2	199.4	157.5	175.8	602.2	1.1	202.4	183.8
16	25656.1	203.1	162.4	202.7	152.5	176.1	599.2	1.1	202.8	169.1
17	25670.2	198	168.8	206.8	146.3	177.1	626.5	1.2	203.1	173.3
18	25754.3	203.1	164.9	200.2	148.3	178.5	600.1	1.1	199.3	174.2
19	26610	207.2	165	206	154	180	605	1.1	207.5	174.2
20	26932.6	196.2	177.9	202.7	157.3	182.4	617.2	1.1	201	182.6
21	27605.9	222.3	159.2	215.8	145.9	183.4	620.4	1.1	217	161.9
22	28251.2	202.9	183.4	224.8	172.2	187.6	725.5	1.5	225.6	192.8
23	29134.9	219	174.5	212.2	157.2	189.9	642.1	1.1	209.7	179.8
24	33090.7	218.3	197.9	221.9	180.7	203.2	666	1.1	218.2	199.4
25	34745.9	219.9	205.5	241.7	185.4	206	762.2	1.3	226.8	208.8

G. rubescens GLOW 3 BoxTop Hole 2

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	14925.2	146.6	130.5	150.2	125.9	135.6	436.6	1	152.2	135.7
2	18123.4	173	134.5	169.2	121	148.9	494.7	1.1	170	139.2
3	18123.4	162	143.7	161.7	133.4	148.9	484.5	1	162	149.8
4	19007.1	173.7	140.6	173.3	128.9	153.1	507.6	1.1	174	147.6
5	19091.3	168.5	145.7	171	136.3	151.8	513.7	1.1	170	153.9
6	19343.8	164.8	150.8	165.9	141.6	154.3	511.9	1.1	165.5	160
7	19554.2	172	146.5	172.8	137.4	153.5	516.9	1.1	173.7	159
8	19947	174.4	146.6	174.6	139.9	155.9	508.7	1	177.3	153.5
9	20522.1	192.8	136.6	185	119	160.6	528.8	1.1	184.8	136.4
10	21125.3	167.2	162.4	170.2	151	160.2	524.6	1	169.4	158.8
11	21293.6	184.2	149.2	180.8	133.7	160.7	539.1	1.1	179.6	154.3
12	21981	195.7	143.7	194.5	134.9	163.8	544.7	1.1	198.3	149.9
13	22836.6	184.9	158.9	184.9	142.4	167.6	554.9	1.1	182.2	165.8
14	22920.8	191	153.9	191.3	142.8	167.4	554.6	1.1	190.1	159.2
15	25207.3	184.2	176.5	194.8	156.3	177.4	587.2	1.1	186.1	177.8
16	25642.1	189.6	174.4	195.5	152.5	176.7	582.6	1.1	193.9	185.3
17	26259.3	195.1	173.3	197	159.7	179.6	593.7	1.1	197.2	181.7
18	26750.3	193	184.1	199.8	169.5	185	619.3	1.1	192.9	184.6
19	26764.3	196.7	176.2	203.1	161.6	180.6	607.9	1.1	203	187.7
20	29625.9	217.1	178.2	225.3	165.6	191	654.1	1.1	226.3	192.8
21	30341.3	215.3	181.8	222.5	164.2	193.2	657.2	1.1	224.8	198.9
22	30579.8	221.9	178.1	225.5	170.8	192.4	666.8	1.2	225.2	188.4
23	31659.9	211.1	195.7	217.3	174.9	197.3	667	1.1	219.5	208.3
24	33932.3	230.8	189.3	233.7	172.7	204.1	680	1.1	237.3	205.7
25	38322.9	239.5	206	247.2	192.2	216.7	728.8	1.1	247.9	216.7

G. rubescens GLOW 3 BoxTop Hole 3

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	13676.7	146	124.4	142.6	108.9	130.8	436	1.1	145.4	124.2
2	14308	148.5	123.6	149.9	117.5	133.5	434.5	1.1	149.9	131.2
3	14364.1	152.4	121	150.2	114.6	132.8	433.9	1	150.1	125.4
4	14869.1	148.1	129.6	147.4	117.3	134	447	1.1	150.4	136.2
5	15065.4	153.5	125.7	152.8	119.5	135.1	443.8	1	152.7	129
6	15963.2	154	135.9	151.5	117.6	140	469.8	1.1	154.8	134.3
7	17001.2	153.4	147.2	154.3	127.3	147.2	486.3	1.1	154.7	142.1
8	17099.4	156.3	141.3	162.1	119.2	146	485.6	1.1	160.7	148.9
9	17408	155.5	147.2	161	133.4	148.7	486.2	1.1	161.7	155.3
10	17492.2	163.4	137.6	166.3	129.8	145.1	491.6	1.1	166.2	152
11	18516.2	159.1	150.2	157.7	137.7	149.9	498.6	1.1	160.9	149.3
12	18614.4	161.1	149.2	165.8	124.5	150.2	504.5	1.1	158.3	146.6
13	19456	168.1	148.3	169	138.1	155	506.2	1	169.2	152.3
14	19624.4	171.3	147.6	175.4	137.4	155.1	520.6	1.1	174.8	157.7
15	19947	168.1	153.2	172.9	131.9	156.7	522.3	1.1	163.8	151
16	20620.3	179.6	148.4	179.8	132.4	158.5	531	1.1	182.2	155.1
17	20788.6	178.2	152.3	176.5	135.8	159.8	539.8	1.1	172.8	157.7
18	21223.5	180.9	151	182.9	134.3	160.6	534.9	1.1	184.3	161.6
19	21910.8	190.3	148.4	199.8	137.4	163.1	564	1.2	198.4	153.6
20	23243.4	193.2	155.2	192.8	143.1	169	571.6	1.1	196.2	167.4
21	23776.5	188.2	162.5	191.6	156.9	170.4	567	1.1	189	171.7
22	23944.8	201.6	152.6	201.3	137.4	170.8	567.9	1.1	199.1	158.9
23	25964.7	201.2	165.5	195.4	148.2	178.8	586.8	1.1	190.8	161.1
24	30986.6	218.4	184.1	214.7	170.4	196.6	648.6	1.1	215.5	193
25	33623.7	210.7	208.8	215.1	192.8	203	693.7	1.1	214.5	210.5

G. rubescens GLOW 3 BoxTop Hole 4

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	13957.3	137.4	134.7	137.7	127.2	132.9	436.1	1.1	137.3	137.3
2	14953.2	148.9	128.6	148.2	114.6	135.6	441.9	1	147.7	129.3
3	15051.4	143	135.5	144.7	124	136.1	440.7	1	146.8	143.3
4	16832.9	165.2	131.2	163.2	117.5	143.4	479.1	1.1	159.8	134.6
5	16917.1	163.4	133.9	165.8	125.9	143.1	480.2	1.1	166.7	140.2
6	17127.5	157.4	140.4	160.1	130.4	146	477.9	1.1	157.5	146.3
7	17464.1	155.7	144.4	155.8	135.7	146	473.5	1	156.3	149.9
8	18109.4	172	136.9	173.3	126.7	148.4	502	1.1	175.5	140.3
9	18137.4	164.1	144.9	164.8	132.4	150.3	495.1	1.1	159.7	148.7
10	19498.1	180.9	138.6	179.5	127.2	154.9	523.7	1.1	181.5	146.9
11	20311.7	181.4	144.6	177.5	130.7	157.1	523	1.1	176.6	147.3
12	20395.9	171.8	155.2	169.7	143	158.4	533.7	1.1	173.1	157.3
13	20480	173.8	156.5	173.2	144.1	160.9	531.9	1.1	177.1	154.9
14	20522.1	176.4	149.2	176.7	142.3	158.3	518.3	1	177.3	153.6
15	20718.5	175.2	153.2	176.5	147.6	160.6	535.5	1.1	180.2	162.1
16	21363.7	188.2	145.6	181.5	135	162.2	544	1.1	183.5	148.6
17	21532.1	175.9	160.7	172.8	151	163.3	535.8	1.1	176.9	161.8
18	21602.2	187.3	148.5	186.1	137.5	161.8	540.6	1.1	185.8	155.9
19	21616.2	177.1	157.2	177.5	144.1	161.9	538.6	1.1	175.3	157.4
20	22724.4	190.6	155.2	192.3	147.4	168.2	560.4	1.1	192.4	163
21	23804.5	184.2	166.2	188.2	151.5	170.6	568.4	1.1	187.4	176.2
22	24000.9	189.4	163.8	195.4	153.7	171	577.8	1.1	195.4	175.9
23	26231.3	217.3	155.3	214.3	145.4	179	605.1	1.1	214.7	161.1
24	28587.9	202.4	182.8	206.8	158.9	186.8	632.9	1.1	207.9	186.2
25	36485.3	247.8	194.7	244.9	176	213.6	726	1.1	246	204

N. humerosa.dutertrei GLOW 3 BoxTop Hole 1

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	95133.9	378.8	326.3	384.3	266.7	344.2	1190.1	1.2	370	335.2
2	100591	378.6	340.9	391	310	353.7	1174.5	1.1	377	339.5
3	102653	381.7	344.5	388.8	308.3	357	1195.9	1.1	387	349.5
4	108502	403.9	344.8	403.9	308.2	366.7	1227.8	1.1	401.8	363.7
5	109680	404.6	350.9	404.4	277.4	367	1288.5	1.2	407.1	364.8
6	117746	424	357.3	420.1	309.9	382.5	1274.3	1.1	426.5	362.6
7	118518	420	361	429.3	348.4	384.2	1291.3	1.1	431.2	373
8	125068	436.8	372	433.1	302.7	391	1407	1.3	439.8	379.6
9	130343	434	387.2	443.7	362	403.7	1334.5	1.1	423.3	388.3
10	131269	435.8	387.2	436.2	344.9	404.3	1346.5	1.1	429.1	392
11	131605	442.2	382.1	434.4	354.5	404.6	1337.6	1.1	443.3	380.4
12	132769	460.4	370.9	466.4	348.3	405	1366.6	1.1	466.9	393.3
13	141438	467.4	389.3	468.2	333.9	418.5	1414.2	1.1	472.5	406.9
14	150879	486.4	399.4	481.1	368.8	432.2	1468.2	1.1	486.1	399.8
15	155788	491.4	407.7	489.7	356.8	439.4	1473.5	1.1	469.6	409.2
16	157752	463.2	437.9	478.5	389.5	443.1	1515.7	1.2	485.4	442.2
17	160642	492.8	422	485.6	351.5	447.6	1536.7	1.2	489.4	432
18	162437	520.5	399.7	517.7	375	448.2	1509.6	1.1	519.5	407.1
19	163574	496.1	429.6	497.3	384.6	453.9	1544.8	1.2	498.3	428.8
20	171261	495	444.8	505.9	427.5	463	1551	1.1	502.5	458.1
21	195065	544.3	461.3	550.5	419.8	492.9	1669.6	1.1	543.6	477.2
22	198698	543.8	471.6	554.6	437.9	496.9	1698.8	1.2	554.7	485.5
23	203987	561.2	484.2	557.2	423	512.9	1745.2	1.2	560	494.1
24	213189	542.6	503.5	560.8	452.1	516.7	1715.7	1.1	559.1	539.3
25	230709	572.6	518.9	583.9	465.6	536.3	1819.9	1.1	583.4	526.9

N. humerosa.dutertrei GLOW 3 BoxTop Hole 2

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	84543.2	366.1	297.8	369.9	235.7	321.9	1107.5	1.2	361.3	301.5
2	87713.4	361.3	311.2	364.5	277.3	329.5	1094.1	1.1	358.2	311.7
3	90350.6	368.9	316	377.2	280.7	334.9	1126.7	1.1	370.5	329
4	95526.7	392.2	313.1	406	287.2	343.3	1169.4	1.1	388.2	322.7
5	107113	393.1	349.5	406.2	316.1	365.2	1218.5	1.1	398.7	358.2
6	109260	419.8	335.4	421.1	270.1	366.3	1286.3	1.2	415.2	338.3
7	110592	416.7	340.1	419.5	313.3	370.1	1377.9	1.4	420.7	350
8	123315	460.7	343.5	457.3	289.8	389.5	1348.8	1.2	457.7	374
9	127846	464.3	353.5	463	310.6	397	1377.9	1.2	462.5	359
10	127930	447.5	366.8	451.3	345.7	398.1	1368	1.2	456	383.6
11	133331	448.7	380.3	456.2	353.4	406.9	1366.2	1.1	454.5	382.6
12	138394	468.4	381.1	479.5	344.3	413.2	1422.6	1.2	478.1	394.8
13	138745	439.8	406.1	451.5	367.7	415.4	1426.5	1.2	450.9	431.9
14	139587	474.6	379.1	472.2	346.9	415.4	1415.2	1.1	475	389.3
15	156784	470.7	426.1	483.2	397.2	442.2	1471.6	1.1	482.9	436.9
16	165411	508.9	418	509.4	360.2	452.7	1561.2	1.2	514.2	431.1
17	171541	521.9	426.1	561.7	388	459.5	1752.1	1.4	565.1	481.6
18	179537	511.6	449.6	516.8	412.1	473.2	1608.9	1.1	492.7	462.8
19	186677	530.8	451.3	539.1	418.6	483	1672.9	1.2	531.1	477
20	196889	590.7	428	587.3	387.4	492.7	1785.1	1.3	588.9	441.3
21	201911	545.9	474.5	552.1	449.3	501.6	1678	1.1	547.9	493.7
22	220806	578.5	489.4	597.3	469.5	524.4	1766.9	1.1	592.5	506.4
23	240472	598.1	515	622	479.4	548.4	1984.9	1.3	620.3	574.1
24	262635	647	523.1	670.9	442.7	570.4	2019.2	1.2	660.5	553.9
25	266619	616	555.9	624	484.8	577.5	1953.2	1.1	616.1	567.4

N. humerosa.dutertrei GLOW 3 BoxTop Hole 3

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	74639.8	341.1	281.5	333.5	236.9	303.4	1010.9	1.1	333.4	275.3
2	76196.9	338.3	288.7	331.1	252.5	307.3	1019	1.1	334.2	284.7
3	77066.6	361.5	275.6	361.3	226.3	306.5	1066.6	1.2	354.8	285.7
4	97181.9	379.9	328.1	379.2	291.9	347	1147.7	1.1	376.9	325.6
5	99370.2	397.6	320.3	402.9	305.9	350.4	1166.7	1.1	403.1	341.6
6	102554	408.4	321.3	409.1	291.8	355.8	1175.5	1.1	408.6	327.9
7	110031	391.9	359.6	397.2	335.5	369.5	1230.9	1.1	386.6	368.8
8	110704	408.8	348.4	416.2	312.5	369.7	1272.9	1.2	405.1	351.6
9	116736	427.4	351.2	427	332.7	380.3	1265.4	1.1	431.1	354.1
10	120383	433	356	429.3	317.8	386	1305.3	1.1	425.3	374.4
11	121842	447.8	350.1	449.5	334.4	387.3	1340.9	1.2	451	366.6
12	126864	429.1	382.5	443.9	362.9	398.4	1335.3	1.1	428.7	389
13	127537	438.6	374	429	321	397.2	1353.4	1.1	435.7	371.3
14	130020	452.3	369.7	465.7	337.6	400.7	1372	1.2	468.3	397.3
15	130245	437.5	382.7	433.5	351.1	401.9	1361.5	1.1	432.8	391.9
16	133569	467	370.6	463.2	320.1	404.5	1411.6	1.2	453.9	396.6
17	135884	461	379.2	472.1	316.5	410.1	1404.6	1.2	464	388.3
18	149406	468.7	408.8	491	380.8	430.9	1448.1	1.1	487	434.4
19	161231	514.7	402.7	520.9	353	446.5	1520.3	1.1	518.6	422.3
20	194560	535.8	474.4	546.8	462	497.9	1718.6	1.2	555.1	503.1
21	197183	548.9	465.1	561.3	399.9	497.3	1769.3	1.3	554.1	478.9
22	209107	585	458.7	595.9	441.7	509.5	1724.9	1.1	596.4	478.1
23	215082	590.5	466.2	601.9	454.1	517.7	1735.8	1.1	601.9	485.9
24	221661	565.4	506.3	578.1	457.6	528	1843.6	1.2	590	528.1
25	233613	583.4	521.6	608.1	447.7	544.4	1843.8	1.2	569.9	545.6

N. humerosa.dutertrei GLOW 3 BoxTop Hole 4

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	51312.3	279	235.8	279.9	214	250.9	834.4	1.1	272.5	242.9
2	65423.8	319.1	264.6	312.8	220.5	283.6	965.1	1.1	315.7	270.6
3	70501.8	341.6	267	338.3	251	295.7	991.4	1.1	336.1	278.9
4	79759.9	355.1	287.9	360.3	268	313.4	1054.2	1.1	359.8	303.3
5	90659.2	374	311.2	377.7	293	334.6	1110.2	1.1	368.6	326.1
6	95737.1	377.6	328	377.2	261.5	343.6	1179.6	1.2	367.9	327.6
7	98191.9	390.5	323.5	393.3	298.2	347.8	1176.6	1.1	388.4	341.7
8	100703	386.7	335.2	399.6	280.5	352.9	1195.7	1.1	397.1	353.6
9	100885	403.8	320.4	402.8	296.3	352.8	1191.6	1.1	394.3	331
10	102877	379.4	349	391.7	310.6	356.9	1212.6	1.1	370	353.5
11	103073	413.3	321.2	417.5	268.1	355.8	1224.9	1.2	415.7	338.6
12	106608	402.2	341	396.7	295	363	1223.8	1.1	403.9	337.8
13	108909	414	340.1	409.1	299.6	365.6	1256.6	1.2	410.6	360.1
14	113636	398.6	367.5	429.2	337.1	375.7	1333	1.2	409	372.3
15	118237	411.6	370.5	421.5	346.3	382.6	1296.8	1.1	420	387.4
16	118742	395.7	384.8	401	356.1	384.7	1259.1	1.1	406.6	397
17	128477	472.8	349.6	470.3	318.4	397.5	1341.3	1.1	466.9	362.8
18	135435	443.7	393.1	441.6	366.8	409.8	1412.3	1.2	452.2	412.1
19	139559	453.5	393.9	453.3	357.1	416.4	1392.2	1.1	445.4	392.3
20	147274	458.9	412.5	460.9	350.2	427.6	1448.5	1.1	437	416.9
21	159057	471.9	432.6	491	413.4	445.4	1478	1.1	488.7	444.2
22	166786	498.5	429	515.6	412.4	455.8	1511	1.1	515.3	454.8
23	167936	531.6	407.9	538.1	370.8	454.6	1569.5	1.2	544.5	440.5
24	168034	498.1	434.7	508	410.7	457.4	1540.5	1.1	501.5	444.8
25	233949	601.4	506.2	618.5	478.1	542.4	1822.5	1.1	618.5	532.3

G. woodi 872C 7H 6 95-97 Hole 1

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	20059.2	168.8	152.7	171.9	137.7	156.9	512.7	1	170.9	159.1
2	20143.4	162.5	159.7	168.3	141.2	157.5	519.4	1.1	169.3	169.3
3	20395.9	182.7	142.6	177	124.5	157.8	517.3	1	176.8	139.4
4	20914.9	177.1	154.6	177.5	142.4	162.2	536.7	1.1	177.2	161.7
5	21447.9	179.8	154.4	176.5	144.5	162.9	532	1.1	177.8	159.4
6	21658.3	177.2	157.2	173.3	149.2	163.1	528.5	1	173.7	159
7	22107.2	179.8	162.2	183.6	154.2	167.3	547.5	1.1	181.8	166.4
8	22696.4	185.3	157.4	184.5	148.7	166.9	552	1.1	186.6	166.1
9	22878.7	188.3	155.3	187.3	146.5	166.5	543.9	1	185.8	160.1
10	23089.1	186.9	158.5	184.1	144.6	169.2	555.9	1.1	183.2	161.7
11	23159.3	196.4	150.6	191	133	168.5	554	1.1	191.9	146.7
12	25053	193.6	165.8	190.3	156.3	176	570.4	1	190.8	170.5
13	25235.3	190.8	169.9	195.7	162.3	175.6	582.1	1.1	195.6	176.7
14	25614.1	191.1	174.2	194	162.8	177.6	592	1.1	194.5	181.1
15	25698.2	193.4	173.5	191.3	164.5	179.3	593.2	1.1	188.9	177.8
16	25796.4	192.1	176.6	194.8	166.4	180.9	595.2	1.1	197.3	184.1
17	26694.2	199.3	176.5	204.9	165.8	182.6	611.1	1.1	207.8	180.4
18	27311.4	207.7	172.6	202.7	154.3	185.9	604.3	1.1	205.3	173.4
19	27479.7	207.3	173.1	208	165.6	184.9	613.9	1.1	210.4	181.5
20	30930.4	221.8	178.7	213.2	161.7	193.8	645.3	1.1	214	180.7
21	31042.7	216.6	183.6	214.3	172.3	194.5	644.9	1.1	213.7	188.9
22	31926.4	232.9	176	228.5	158	197.5	656.9	1.1	229.5	182.1
23	34198.8	229.1	193.7	226.7	175.6	205.5	689	1.1	223.5	199
24	34339.1	227.2	193.8	227.4	180	205.1	686.2	1.1	226	203.9
25	39992.1	258.2	198.1	254.7	181.5	221	732.7	1.1	254.7	202.1

G. woodi 872C 7H 6 95-97 Hole 2

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	17786.8	157.6	145.2	159.7	139.4	147.2	483.4	1	152.9	145.3
2	18432	166.3	143.5	168.2	130.8	150.9	493.7	1.1	171.2	149.1
3	18768.7	170	142.1	170.6	132.7	150.2	504.4	1.1	170.5	151.5
4	19371.9	177.8	140	177	134.3	153.9	509.8	1.1	176.5	146.6
5	19652.4	168.5	149.8	167.7	141.2	154	512.8	1.1	164.9	153.7
6	20886.8	184.8	147.4	180.7	136.3	161.3	531.7	1.1	180.7	153
7	21756.5	179.2	164	183.7	154.4	168.2	561.5	1.2	187.2	169.2
8	21896.8	192.8	145.3	189.6	137.7	164.4	536.2	1	191.7	149.1
9	21952.9	182	156.4	176.7	142.6	163.8	544.6	1.1	176.9	160.2
10	21981	186.2	151.4	184.9	140.8	164.5	540.1	1.1	185.5	157.2
11	24491.9	188.3	170.2	186.4	157.5	174.8	576.4	1.1	185.3	173.5
12	24548	197.9	159.3	198.8	152.8	172.3	575.4	1.1	198.9	168.8
13	27381.5	199.7	178.6	199.4	162	183.9	608.8	1.1	199.7	187.5
14	27774.3	207.7	172.3	207.4	163.6	184.6	611.4	1.1	202.6	180
15	28896.5	206.3	180.6	203.8	162.5	188.1	623.1	1.1	204.2	186.2
16	29808.3	218.6	174.8	217.3	164.8	191.5	630.9	1.1	217.4	177
17	30818.2	228.7	173.3	225.5	160.9	192.7	654.8	1.1	225.4	180.5
18	31211	218.6	182.9	218	171.8	195	638.1	1	217.3	187.4
19	31519.6	211.1	197	216.7	182.9	199.6	662.2	1.1	215.8	210.2
20	32319.2	222.6	186.1	220.4	176.1	198.4	652.9	1	220.3	191.3
21	33581.6	233.4	185.5	227.4	172.3	202.9	676.7	1.1	227.3	190.5
22	34100.6	219.3	200.3	221.8	188.3	204.6	697.9	1.1	220.9	206.1
23	35096.6	241.8	188.7	238.2	171.8	207.4	699.9	1.1	237.4	196
24	35363.1	245.4	186.8	243.5	169.6	208.6	703.8	1.1	243.7	192.5
25	42432.9	268.9	202.5	263.5	173.3	227.8	763.1	1.1	264.1	202.8

G. woodi 872C 7H 6 95-97 Hole 3

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	19217.6	170.1	145.3	168.2	136.3	153.3	507.3	1.1	169.2	154.2
2	19947	172.5	149.2	172.9	143.4	157.1	512.2	1	173.6	157.2
3	21027.1	182.5	151.5	183.7	142.4	161.4	537.7	1.1	183.3	157.1
4	21195.4	182.9	148.1	180.8	142.3	160.6	525.2	1	182.2	152
5	21798.6	186.6	154	184.5	143.4	166.3	548.1	1.1	183.8	157.6
6	21952.9	182.6	155.8	183.6	149.2	165.3	537.4	1	184.1	161.5
7	22822.6	181.4	168.3	180.4	153.7	169.9	568.9	1.1	184.5	170.9
8	23383.7	181.2	167.1	182.9	156.4	169.8	563.7	1.1	185.9	174.3
9	23524	182.8	169.5	181.2	159.3	170.4	569.2	1.1	179.9	177
10	23902.7	188.6	163.1	188.6	155.9	170.9	569.6	1.1	190.6	172
11	24758.4	195.5	162.2	196	158.4	174.2	571.1	1	196.7	169.7
12	26119	199.8	171.7	203.5	162	181.2	604	1.1	203.1	180.9
13	26385.6	202.7	167.1	202.7	157.5	179.4	597.9	1.1	201.1	171.4
14	27423.6	206.2	173.9	202.6	158.4	185.6	611.2	1.1	202.6	179.3
15	27676.1	201.8	176.1	202	165.9	183.7	606.2	1.1	198.8	180.7
16	27914.5	200.7	182.5	200.2	162.6	187.3	623	1.1	200.8	190.7
17	28349.4	212.9	173.6	214.5	165.9	187.9	626.5	1.1	215.4	185.2
18	28475.6	211.3	173.5	211.4	165.9	185.4	622.9	1.1	211.2	180.8
19	29036.7	210.6	178	208	162.6	188.4	624.1	1.1	203.9	183.3
20	29766.2	219.6	173.9	219.3	164.5	191.1	639.9	1.1	219.2	181.1
21	30397.4	218.4	180	214.5	165.9	193	652.6	1.1	213.6	190.5
22	30537.7	214.2	183.7	212.8	165.3	193.1	640.8	1.1	208.5	190.6
23	30607.8	219.9	179.3	218.8	168.2	193.6	649.9	1.1	219.7	189.6
24	34703.8	234.1	194.6	233.7	186	208.7	696.7	1.1	235.8	203.3
25	39445.1	245.8	207.8	242.9	191	221.5	732.8	1.1	239.5	214.5

G. woodi 872C 7H 6 95-97 Hole 4

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	15977.2	157	134.2	158.4	130	143.9	466.4	1.1	160.6	141
2	17870.9	163.8	139.9	165.5	132.8	147.6	486.1	1.1	166.7	147.6
3	21686.4	172.8	162.6	172.9	148.2	163.2	536.8	1.1	170.5	169.2
4	22485.9	171.5	169.2	176.7	151.8	166.5	536.8	1	169.2	165.3
5	23019	190.2	157.2	188.6	146.5	167.7	566.2	1.1	188.7	163.8
6	23075.1	187.2	160.2	191	154.2	169.1	560.1	1.1	191.7	168.2
7	23187.3	189.4	156.9	188.6	149.1	168.4	553.6	1.1	188.9	163.7
8	25978.8	189.9	180.9	192.8	167.4	180.9	607.9	1.1	194.7	185.8
9	26469.7	199.5	170.2	199.1	158.7	180.3	596.2	1.1	195.6	173.2
10	26638.1	201.3	169.6	195.3	156.4	179.6	594.4	1.1	192.9	170
11	27143	204.6	170.5	202.8	159.7	181.6	602	1.1	201	177.5
12	27521.8	209.7	169.4	207.4	162.6	183.9	607.7	1.1	207.9	178.5
13	28082.9	202.5	177.9	203.5	161.6	185.5	609.7	1.1	202.6	183.4
14	29625.9	204.7	189.9	206.8	181.2	192.9	635.6	1.1	207.1	194.8
15	30215	211.3	189.5	214.5	174.6	195.8	646.6	1.1	216.3	190.1
16	31267.1	221.1	181.5	221.9	172.9	195.9	650.1	1.1	222.4	191.6
17	31772.1	213.2	193.9	213	180.8	198.4	652.5	1.1	217.6	194.6
18	32333.2	217.2	192.6	220.5	182.6	198.7	667.9	1.1	219.9	203.6
19	33918.3	236.6	191.1	237	179	207.5	696.8	1.1	239.9	198.1
20	33946.3	220.7	197.6	224.8	182.9	203.5	669.7	1.1	226.1	202.6
21	34212.9	223.8	197	223.9	184.2	204.8	686.8	1.1	222.3	209.3
22	34269	224.9	195.7	221.9	182.9	205.3	675	1.1	219	199.3
23	35685.7	232.1	199.4	236.5	182.9	208.7	714.7	1.1	236.5	208.2
24	37803.9	242.9	201.3	241.7	185.5	214.9	725.3	1.1	240.6	211.6
25	38729.7	253.6	199.7	256.4	191	219.8	740.8	1.1	256.5	209.7

G calida GLOW 3 BoxTop Hole 1

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	36148.6	241.4	194.8	248.3	175.9	209.3	740.4	1.2	248.8	215.8
2	40791.7	268.6	197.3	263	152.8	222	788.5	1.2	261.4	207.1
3	47384.6	274.1	224.8	279.2	208.7	239.7	859.4	1.2	282.4	245.3
4	50302.3	279.1	234.7	286.6	212	247.3	869.4	1.2	291.2	257.5
5	60752.7	311.9	252.5	321.7	217.9	272	964.8	1.2	314.6	268
6	61327.8	300	264.4	309.2	231.4	275.1	952.6	1.2	304.6	271.3
7	63291.7	318.8	258.6	333.3	233.2	277.5	988.6	1.2	334.9	283.4
8	63614.3	308.6	269.1	319.8	235.8	279.9	991.4	1.2	322.1	281.5
9	67556	346	253.3	356.8	237.9	286.3	1017.9	1.2	360.9	280.7
10	69435.7	345.6	261.1	350.7	228.5	289.8	1050.6	1.3	353.3	288.4
11	78637.7	324.5	315.1	344.6	273.8	310.8	1110.2	1.2	327.2	318.7
12	79437.2	388.4	267	378.3	212	308.9	1179.3	1.4	380.7	282
13	86086.2	380.7	296.7	389.3	268	322.3	1191.1	1.3	389.4	328.9
14	91220.2	391.7	303.4	403.4	278.1	332.9	1193.7	1.2	404.1	339.7
15	94095.9	407.1	301.4	421.9	276.2	338.2	1228.4	1.3	423.8	341.8
16	96129.8	407.8	306.6	420.1	289.6	341.9	1226	1.2	422.2	341
17	103873	434	312.6	440.9	263.5	353.2	1307.4	1.3	440.6	353
18	118532	443.4	351.1	463.5	308.3	379.2	1414.2	1.3	464.4	394.8
19	134425	490.8	358.7	504.6	326.6	402.6	1491	1.3	512.9	403.3
20	137188	532.2	338.2	519.9	254.7	403.7	1515.8	1.3	520.2	364.8
21	144665	497.2	387.3	518.6	304.6	415.9	1646.9	1.5	521	431.4
22	152520	495.1	402.8	520.6	340.5	432.5	1569.1	1.3	518.2	440.5
23	197324	635.6	417.6	648.5	338	481.2	2100.5	1.8	648.7	498.3
24	222306	632.9	467.4	650.1	345.2	522.4	2038.1	1.5	637.3	513.7
25	235226	655.4	473.3	660	369.5	532.2	2038.6	1.4	653.9	530.1

G calida GLOW 3 BoxTop Hole 2

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	64371.8	327.2	254.2	332.9	245.3	280.3	976.6	1.2	334.9	274.8
2	72437.5	338.1	281.2	338.1	249.8	297.7	1083	1.3	335.2	295.7
3	77599.6	362.7	279.3	376	223.4	305.7	1123.5	1.3	374.8	308.1
4	83322.8	367.4	296.5	383.9	244.9	318.5	1153.8	1.3	384.2	327.5
5	89144.2	375.1	307.8	389.7	286	331.2	1157	1.2	389.4	337.1
6	89326.6	366.8	317.2	385.8	279.8	330.7	1188.5	1.3	386.2	346.4
7	97322.2	444.7	285.1	443.7	248.2	340.8	1309.1	1.4	444.5	311.3
8	110199	431	336.9	442	285.5	366.5	1352.8	1.3	441	364.4
9	110887	426.6	339.8	436.4	302	367.1	1353.3	1.3	442.6	372.6
10	113538	442.8	336.2	485.5	295.6	371.4	1430	1.4	484.9	376.7
11	117059	419.1	367.7	442	321.3	377.5	1405.4	1.3	449.7	397.8
12	121772	466.2	338.9	469.2	298.5	384.4	1396.4	1.3	469.4	367.1
13	126233	484.7	339.8	496.4	294.5	390.2	1448.8	1.3	499.3	374.2
14	129768	478.4	354.8	483.1	279.2	396.6	1497.5	1.4	485.8	389.8
15	160937	516.6	411.5	546.8	321.8	441.8	1700.5	1.4	550	461.6
16	165860	556.2	395.4	572	361.5	445.8	1732.1	1.4	572.9	458.6
17	177180	535.1	434.6	557.5	268	464.3	1840.6	1.5	531.2	447.6
18	185344	545.7	443.7	576.6	310.6	476.6	1817	1.4	562.8	474.4
19	199273	546.9	478.2	570.3	393.6	498.7	1916.6	1.5	546.9	482
20	201925	549.1	480	610.1	378.7	499.4	1857.3	1.4	588.1	502.8
21	217663	588.1	483.6	608.2	389	517	1972.5	1.4	564.9	480
22	226360	611.3	487	644.2	429.3	526.5	1977	1.4	645.3	547.6
23	243193	617.9	514.5	650.4	433.5	546.7	1988.8	1.3	646.6	548
24	293608	697.5	554.3	702.5	440.5	595.9	2341.4	1.5	724.2	587.6
25	349717	804.9	591.2	894.2	321.8	634.6	3067.3	2.1	871.7	645.5

G calida GLOW 3 BoxTop Hole 3

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	50807.3	295.4	223.9	300.8	202.3	247.3	891	1.2	301.7	246.9
2	81401.1	368.5	288.2	375.7	255.7	314.6	1150.6	1.3	375.1	316.1
3	89116.1	397.3	289.5	390	256.4	330	1151.4	1.2	389.6	302.4
4	94755.2	410.9	298.7	413.6	282.4	340.6	1179.5	1.2	413.4	328.5
5	100549	429.8	302.3	420.8	225.3	348.8	1247.1	1.2	415.9	313.8
6	125167	471.6	347.1	485.7	317.3	389.5	1445.9	1.3	486.9	400.6
7	146643	493.3	389.9	523.7	303.3	422.6	1575	1.3	514.9	425.7
8	172481	515.2	433.9	534.3	358.4	461.7	1771.1	1.4	496.4	432

G.bisphericus.P.sicanus 872C 11H 6 20-22 Hole 1

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	54706.9	290.3	240.9	283.6	221.7	259.7	848.5	1	283.9	243.8
2	55969.4	285	250.4	281.6	236.9	263.1	846.2	1	281.2	247.5
3	65620.2	320	262.9	314.1	241.2	283.8	944.3	1.1	313.5	270.4
4	67289.5	324.4	265	318.4	241.8	288.5	945.1	1.1	317.9	263.5
5	69085	316.2	278.6	310.3	265.9	292.6	940.9	1	308.1	277.7
6	70417.6	324.7	277	320.5	239.3	295.2	967.2	1.1	317.7	272.2
7	71666	342.9	267.4	333.2	237.3	296.6	991.3	1.1	337.6	268.7
8	74527.6	336.7	282.6	331.4	271.2	303.7	990.3	1	330.6	286.6
9	74752.1	338.8	281.6	336.4	260	304.2	1012.7	1.1	336	289.7
10	78132.7	337.4	295.5	337.1	279.5	311.4	1014.2	1	334.1	300.8
11	81036.3	345.3	299.4	341.5	274.7	317	1025.9	1	340.2	294.2
12	81864	357.8	293.4	357.5	282.1	318.2	1094.6	1.2	357.3	309.1
13	82116.5	357	294.1	354	274.7	318.5	1058.9	1.1	350.4	299.4
14	83603.4	367.7	290.8	359.9	256.4	320.9	1072.5	1.1	360.2	292.5

15	84599.3	354.9	305.5	352.2	278.1	323.9	1084.1	1.1	354	322.2
16	85132.4	356	305	351.5	291.4	325.1	1050	1	351.8	311.9
17	86086.2	368.3	299.7	361.3	270.3	325.5	1121.1	1.2	356	310.9
18	86745.5	364.6	305.3	392.2	290.7	327.5	1130	1.2	386.7	312.9
19	90462.8	379.9	304.1	369.5	272.7	334.4	1105.5	1.1	369.8	297.5
20	92693.1	384.7	308.8	375.2	279.1	337.7	1134.3	1.1	377.5	320.8
21	93787.3	368.2	324.9	365.7	310.9	341.4	1103.3	1	364.5	331.7
22	105262	408.1	329.6	400.8	290.1	360.8	1191	1.1	398.8	330.2
23	106594	406	335.5	400.4	321.9	363.6	1189.9	1.1	401.4	343.4
24	110732	411.8	343.4	410.3	302	370.6	1238.5	1.1	410.8	349.8
25	128814	460.5	357.3	453.3	322.6	399	1324.3	1.1	449.6	357.1

G.bisphericus.P.sicanus 872C 11H 6 20-22 Hole 2

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	59490.2	295.3	257.2	297	228.8	271.3	885.6	1	289.7	256.4
2	65437.9	315.6	264.5	314.4	242	284.5	935	1.1	309.7	263.9
3	68958.7	326.9	269.6	318.9	238.9	291.5	962.6	1.1	315.1	260.2
4	69309.4	316.1	279.9	311.2	245.4	293.3	960.1	1.1	311.6	276.9
5	71694.1	330.1	277.1	325.6	251.2	297.6	968	1	325.7	273.6
6	71932.6	326.4	281.3	325.4	266.6	298.4	971.5	1	326.2	286.3
7	72704.1	329.7	282.2	325.8	258.4	299.7	1006.7	1.1	324.1	290.7
8	74541.7	341.1	279.1	336.5	258.4	303.4	988	1	336.1	280.8
9	76505.5	335.4	291.1	336.7	270.1	307.7	1011.5	1.1	336.7	292
10	77445.3	336.1	294.1	335.1	273.7	310.3	1008.1	1	333	303.3
11	78385.2	344.5	290.5	338.1	263.5	311.5	1022.1	1.1	336	290.1
12	78385.2	344.2	290.7	336.7	263.1	311.8	1016	1	333.4	283.6
13	80769.8	365	282.9	354.1	236	315.3	1060.7	1.1	350.5	273.1
14	83841.8	350.9	304.6	353.3	281.4	322.4	1053.9	1.1	351.6	303

15	85300.7	362.3	300.6	352.6	280.9	325.2	1061.8	1.1	352	302.6
16	85426.9	364.7	299.1	359.4	278.1	325.3	1073.8	1.1	358.6	296.4
17	88541	364.8	310.3	363.8	293.8	331.3	1098.1	1.1	365.1	321.4
18	88639.2	384.5	295.4	378.3	268.1	330.2	1108.3	1.1	378.5	302.9
19	90112.1	373.5	308.4	364.9	290.1	333.8	1101.7	1.1	360.4	311
20	93422.6	375.2	318.2	369.6	289.3	340.3	1140.8	1.1	369.7	329.9
21	93689.1	377.1	317.1	373.1	291.4	340.8	1117.3	1.1	371.7	315.1
22	96396.4	396.5	310.3	390.2	283.5	345.1	1139	1.1	391.9	312.1
23	104673	411.4	324.9	408.2	285.8	360.3	1205.2	1.1	402.6	316.4
24	108278	411	336.5	410.7	310	366.8	1212.3	1.1	406	339
25	112009	417	343.3	414.4	316	372.5	1230.2	1.1	414.3	341

G.bisphericus.P.sicanus 872C 11H 6 20-22 Hole 3

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	42783.6	252.8	215.7	250.5	202.6	229.3	740.7	1	250.4	212.3
2	46543	269.7	220.4	260	192	239.1	783.7	1.1	261.7	215.2
3	47426.7	269.2	225.1	270.1	195.7	241.2	796.8	1.1	269	227
4	56502.4	290.4	248.1	283.2	227.5	264.2	856.2	1	283.5	239.1
5	58522.4	296.4	251.9	296.3	234.6	268.9	881.3	1.1	298.9	255
6	60149.5	309.1	248.8	300.5	228.2	271.8	905.1	1.1	297.9	249.9
7	61369.9	316.5	248.2	306.8	222.1	274.6	920.8	1.1	304.2	251.6
8	63712.5	303.1	268.1	299	249.6	281.1	914.3	1	300.6	269.2
9	64105.3	324.8	253	313.1	221	280.3	949.8	1.1	310.8	249.1
10	65087.2	319	260.9	311.8	216.7	283.2	948.9	1.1	307.6	255.7
11	65227.5	318.8	262.2	308.7	220.8	283.3	965.7	1.1	309.4	269.5
12	67051	316.4	270.7	310.3	240.4	288	944.9	1.1	308.8	266.9
13	69758.3	333.6	267.3	330.3	248.3	293.2	965.1	1.1	327.8	267.4
14	70908.6	328.4	275.5	323.2	252.7	295.9	963.8	1	320.7	274.3

15	75074.7	345	278	339.4	241.1	304.5	1007.2	1.1	336.3	274
16	76154.8	345.4	281.7	344.6	265.9	307.1	1029.7	1.1	337.6	282.8
17	83140.5	371.7	286.4	358.5	248.3	319.6	1073.1	1.1	354.5	282.4
18	84262.7	363.2	296.4	360.2	266	323	1115.1	1.2	357.5	290.8
19	85174.4	382	286.5	381.5	263.8	323.1	1112.8	1.2	370.4	292.5
20	88022	366.2	307	360.3	267.2	330.1	1094.3	1.1	359.1	307.4
21	89761.4	381.6	300.3	372	273.7	332.8	1094.1	1.1	371.4	294.8
22	89901.7	382.8	300.6	420.4	278.1	333.4	1204.4	1.3	425.2	299.6
23	90715.3	384.8	301.1	374.9	267.4	334.6	1103.5	1.1	375.4	303.8
24	92580.9	388.3	305.8	377.6	255.7	337.6	1194.5	1.2	375.2	313.3
25	109077	420.2	331.7	416	289.9	367.6	1224.2	1.1	417.1	330.8

G.bisphericus.P.sicanus 872C 11H 6 20-22 Hole 4

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	48857.5	285.9	220.4	306.3	182.8	243.8	888.1	1.3	299.6	223.8
2	52139.9	289.8	230	281.5	194.6	253.1	838.8	1.1	279.9	224.1
3	52448.5	279.8	239.6	272.8	219.2	254.1	841.4	1.1	270.7	242
4	52504.6	278.1	241	276.9	217.2	254.5	843.9	1.1	273.6	237
5	52785.1	282.8	238.3	277.2	217.7	255	834	1	277	239.9
6	57540.4	296.3	248.1	289.1	221	266.1	873.3	1.1	284.6	241.8
7	58648.6	300.1	249.5	290.7	218.1	268.7	888.6	1.1	290.6	247.9
8	58845	300.4	251.1	296.5	229.6	268.7	901.2	1.1	296.5	261.4
9	59027.3	299.1	252.3	294.8	232.3	269.5	910.7	1.1	292.3	257.3
10	59658.6	310.2	245.7	303.2	217.7	270.6	887.8	1.1	301.5	240
11	61243.7	314.5	248.5	305.2	229.5	274.7	895.3	1	304.7	244.7
12	65101.2	313.5	265.2	306.8	241.1	283.6	930.6	1.1	304.7	259
13	71609.9	343.6	266.6	334.1	244.6	296.5	987.8	1.1	331.5	270.5
14	73714	338.3	278.3	332.2	245.4	301.9	986.7	1.1	328.7	275.7

15	74752.1	345.2	277.2	338	248.6	303.3	1008	1.1	332.7	274.1
16	75144.8	355.1	271.1	349.9	254.7	303.2	1021	1.1	349.8	281.3
17	75677.9	338.8	285.3	332	254.9	305.8	998.3	1	327.3	275.4
18	76842.2	338.1	290.2	335.2	259.1	308.4	1010.7	1.1	326.2	284.9
19	81849.9	350.6	298.2	347	260	318.6	1058	1.1	345.2	296
20	86801.6	380.8	291.4	369.7	256.4	326.7	1094.1	1.1	367.2	284.7
21	87320.6	349.7	318.7	350.4	305.4	329.7	1086.3	1.1	352.5	330.5
22	87783.5	364.3	310.9	360.2	280.9	328.6	1188.8	1.3	357.1	343.6
23	91963.7	379.8	309.8	381.2	295.9	337.4	1123.3	1.1	381.3	322.2
24	92426.6	367.3	321.2	364.9	300.5	338.7	1140.7	1.1	365.8	334.8
25	95302.2	375.5	324.1	377	292.2	344.2	1202.7	1.2	365.2	332.7

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	21041.1	172.6	156.6	171.9	144.1	160.2	526	1	172	161.5
2	21167.4	182.5	148.2	177.5	142.6	160.5	520.9	1	177.4	150.2
3	21588.2	180.6	153.3	176.1	141.2	163.1	538.8	1.1	173.3	156.2
4	22107.2	177.4	162	180.7	148.3	165.8	547.4	1.1	182.3	165.2
5	24604.1	193.9	162.7	191.9	154.4	172.9	570.8	1.1	193.2	168.8
6	24730.3	186.7	169.3	188.5	162.5	174.1	565.7	1	190	174.9
7	24996.8	196.2	164.7	198.3	151	175.3	586.4	1.1	199.1	168.5
8	25459.8	195	171.2	195.5	157.2	178	600.3	1.1	190.3	175.8
9	25866.5	196.1	171.3	195.4	161.7	179.5	581.9	1	195.4	174.5
10	27367.5	201.4	174.3	198.5	160.8	183.1	599.4	1	196.2	178
11	28910.5	204.6	182.2	207.2	169.5	188.7	617.5	1	206.5	191.3
12	29134.9	206.9	180.4	210.1	172.7	188.9	618.7	1	209.9	188.9
13	29457.6	213.1	176.9	210.6	166.2	189.2	622.9	1	210.3	183.9
14	29948.5	211.1	183.5	210.9	172.9	191.6	632.1	1.1	210	192.3

15	32627.8	219.9	190.3	216.4	180	199.2	653.2	1	213.3	193.4
16	33441.3	222.6	192.3	221.8	183.6	202.5	663.6	1	222.1	195.7
17	34156.7	229.2	191.2	224.8	177.6	204.1	674	1.1	225.2	195.7
18	34451.3	222.8	198.9	225.3	184.4	206.3	674.7	1.1	219.6	203.7
19	35180.7	233.7	193.5	233.3	184.2	208.5	684.3	1.1	233.7	201.8
20	37200.7	238.6	199.7	233.7	186	213.6	705.9	1.1	231.3	203.1
21	37607.5	236.8	203.5	236.9	189.9	214.8	709	1.1	235.1	209.9
22	39178.6	247.1	203.2	246.2	191.9	218.8	719.9	1.1	245.1	207.4
23	39318.8	244.2	207.3	246.5	194.3	219.4	726.4	1.1	246.4	216.9
24	43751.5	258	220	260.2	209.9	233.1	772.1	1.1	259.1	230
25	45925.7	252.6	233.1	258.7	219.2	238	787.1	1.1	257.7	241.1

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	22163.3	182.3	157.3	184.1	146.3	165.5	543.8	1.1	181.9	165.3
2	22710.4	180.7	160.8	183.7	151.5	166.5	538.4	1	184.4	167.7
3	24926.7	195.8	166.4	195.4	152.5	175.6	587.9	1.1	193.9	173.6
4	25024.9	191.6	169.6	188.1	148.7	176	586.7	1.1	193.9	168.7
5	26694.2	199.1	173.2	200.2	167.7	181	593.3	1	200.9	180.7
6	26736.2	194.8	175.5	195.5	169.7	180.4	591.5	1	194.9	181.2
7	27297.3	208.3	167.7	208.7	151	181.2	603.8	1.1	206.5	174.1
8	27998.7	198	181.6	203.5	162	186	609.3	1.1	197.5	187
9	28054.8	195.2	184.6	196.5	172.4	185.3	612.7	1.1	196	188.4
10	29682	217.4	175.3	217.3	169.6	191.2	628.3	1.1	217.3	182.8
11	29808.3	224.2	169.9	221.8	156.4	190.1	628.6	1.1	222.3	172.1
12	29808.3	215.5	176.9	213.5	168.2	190.9	627.6	1.1	214.1	180.4
13	30243.1	210.3	189.9	214.7	177.6	198	648.2	1.1	208.5	195.7
14	31659.9	212.9	191.5	210.8	176.5	196.7	650.2	1.1	212.3	194

15	32221	220.8	189	215.6	171.9	198.6	657.2	1.1	216.5	193.7
16	33385.2	229.6	187.2	228.5	174.9	202.8	667.3	1.1	228.9	191.9
17	33539.5	222.9	192.9	224.8	179.3	202.4	669	1.1	224.3	199.1
18	34395.2	228.7	193.3	226.7	179	204.8	681.2	1.1	225.8	200.8
19	34661.7	217.9	204.2	218.8	191.9	206.1	672.4	1	216.2	202.4
20	35882.1	231.5	198.5	227.1	184.8	209.4	689.2	1.1	221.3	199.1
21	38379	229.2	215.3	229.2	198.5	217	714.6	1.1	227.1	221
22	39052.3	232.4	216.4	233.7	202.7	219.1	719.6	1.1	233.7	216.4
23	40427	244.2	212.9	240.9	200.2	223.1	733.1	1.1	242.5	221.1
24	42138.3	245.2	221.2	246.5	211.1	227.2	757.2	1.1	248.9	231.2
25	42713.5	253.1	218.8	258.3	206	230.7	776.4	1.1	259.8	225.3

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	17478.2	163.3	137.3	175.6	132.8	146.3	500.6	1.1	178.2	144.3
2	20101.3	171.8	150.2	170.8	141.6	156.3	511.1	1	171.1	154.5
3	20101.3	168.6	152.4	169	146.1	156.5	505.3	1	170.2	156
4	20227.5	168.3	153.9	165.6	148.4	157	502.1	1	169.2	157.5
5	23257.5	180.7	164.8	183.6	152.5	169	549.6	1	180.2	168.9
6	23495.9	190.5	158.5	189.3	135.3	170.6	568.5	1.1	188.9	164.2
7	24505.9	186.1	168.4	187.3	161.1	173.7	561.9	1	188	175.6
8	25151.1	187.1	172.7	191	148.2	174	581.7	1.1	184	172.3
9	26385.6	201.3	168.3	201.2	163.6	180.1	590.9	1.1	202.7	173.1
10	26764.3	200.5	171.3	201.3	163.2	180.7	594.2	1	201.5	175.7
11	27269.3	203.2	172.1	202.7	161.4	182.6	606.2	1.1	198.5	176.2
12	28040.8	211.7	169.5	206.4	157.5	184.5	606.3	1	207.3	171.8
13	28265.2	211.4	172.4	207.7	157.3	186.3	618.6	1.1	206.3	178.2

14	28419.5	198.8	184.5	202.6	167.9	187	619.1	1.1	206	188.4
15	28952.6	200.5	188	203	174.6	188.6	629.4	1.1	206.1	192.5
16	29106.9	211.3	177	217.3	163.5	188.8	637.4	1.1	209.9	182.1
17	30832.3	214.1	184.7	210.9	170.4	194	634.2	1	214.3	187.4
18	32782.1	223.5	187.5	218.4	171.8	200.3	654.4	1	215.4	185.3
19	33048.6	214.6	197.9	215.1	180.7	201	663.9	1.1	211.6	203.3
20	33693.8	223.9	198.7	225.8	186	206.2	687.5	1.1	226.1	206.8
21	34002.4	221.4	196.9	222.8	188.1	204.2	668.5	1	223.1	202.6
22	36681.7	243	195	244.6	186.6	212.8	713.9	1.1	244.6	206.9
23	36962.2	236.1	200.2	230.2	187.3	212.7	694.4	1	229.6	199.7
24	40483.1	250	207.4	247.7	199.4	222.8	734.9	1.1	247.5	214.5
25	51410.5	283.6	233.3	286.5	221.9	251.1	844.8	1.1	286.3	248.7

G.woodi.apertura 872C 5H 6 59-61 Hole 4

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	18361.9	162.6	147.9	161.1	134	151.3	496.6	1.1	160.8	153.3
2	19582.3	166.8	150.7	168.2	139.9	153.8	508.5	1.1	165.1	157.6
3	20592.2	171.3	154.2	170.4	147.5	158.9	514.9	1	171.7	157.1
4	22135.3	179.3	158.1	178.7	149.2	164.6	542.4	1.1	179.4	163.1
5	22598.2	180.5	160.3	181.5	154.2	167.2	544.2	1	181.4	166.7
6	23173.3	185.4	160.1	184.1	152.5	167.4	551.6	1	183.7	165
7	23453.8	190.8	159.7	203.5	151.7	170.7	581.2	1.1	203.7	166.3
8	23860.6	192.1	159.5	191.9	150.7	169.7	570.7	1.1	193.5	165.2
9	25698.2	187.8	177.3	188.9	167.4	178.1	577.9	1	191.7	176.3
10	25922.7	191.5	175	190.9	165.9	179.1	584.3	1	193.5	176.4
11	26932.6	199.3	174	197.7	164.2	181.5	597.4	1.1	199.8	180.8
12	27297.3	198.8	177.3	202.7	164.5	182.9	609.3	1.1	201.9	187.5
13	27816.4	202.9	175.2	198.3	163.6	184.5	599.7	1	196.3	174.3

14	27998.7	202.3	180.4	198.5	160.3	186.6	619.2	1.1	203.7	180.1
15	28475.6	201.7	183.6	206.4	173.1	188.7	628.8	1.1	207.5	192.6
16	30046.7	210	183.2	211.1	172.3	191.2	629.9	1.1	211.8	188.5
17	30678	229.9	171.3	221.9	149.9	192.3	649	1.1	219.1	167.1
18	30944.5	221.7	181.2	219.7	172.2	195.6	645.4	1.1	219.3	186
19	31505.6	223.3	180.8	220.3	166.3	197.2	645.6	1.1	216.3	184
20	31884.3	227.2	180.7	221.1	165.9	198.2	652.4	1.1	218	180.4
21	36373.1	240.9	194.1	240.2	179	210.6	704.1	1.1	240	201.8
22	38028.3	247.9	201.1	245.4	190.3	218.5	721.3	1.1	247.4	208.7
23	38449.1	241	204.3	241	179.8	216.9	718.5	1.1	235.3	203.5
24	39627.4	255.7	198.7	253.5	182.9	219.5	735.4	1.1	253.6	209.9
25	47581	268.5	228.7	266	210.1	241.4	805.7	1.1	262.4	235.2

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	26497.8	200.2	173.3	201.7	163.6	181.4	600	1.1	200.6	179.1
2	27255.3	194.7	180.9	193.3	172.4	183.1	599.8	1.1	193.1	184.8
3	27704.1	203.1	178.9	203.5	170.2	185.6	616.8	1.1	206	185.6
4	35938.2	225.5	208.8	227.8	197.7	212.5	697.9	1.1	228.6	210
5	36134.6	226.5	212.9	231.7	193.3	215.6	713.8	1.1	231.5	221.1
6	36920.1	244	199	245.3	192.3	216.8	703.7	1.1	246.3	203.9
7	37326.9	242.2	198.1	245.3	186.6	213.3	715.7	1.1	242.7	206.1
8	38112.5	244.5	204	247.2	191	218	734.5	1.1	245.3	213
9	38687.6	243	206.2	244.6	198.5	218.2	719.2	1.1	245	217.3
10	38771.8	249.3	199.4	242.6	164.5	217	729.6	1.1	243.2	200.7
11	39150.5	249.6	203.4	251.1	194.5	220.4	740.8	1.1	250.8	211.9
12	39473.1	251.1	202.4	248.3	188.2	220.1	737.5	1.1	247	210.1
13	40034.2	249.7	206.7	249	194	221.4	736	1.1	250.4	216.9

14	40623.4	243.7	214.1	243.6	199.4	223.3	756	1.1	246.1	219.9
15	41801.7	242.9	221.8	244.6	210.1	226.1	752.7	1.1	244.9	232
16	42573.2	256	215	252.7	203	229.4	760.2	1.1	250.9	220.6
17	42755.5	258.6	214.8	254.7	199.1	230	768.7	1.1	249.9	220.4
18	43176.4	260.6	214	260	199.7	230.5	773.9	1.1	259.2	218
19	43246.5	250.2	227.5	252.7	214.4	232.6	777.2	1.1	254.4	238.8
20	43835.7	262.5	215.3	263.7	199.1	231.2	796.9	1.2	262.7	229.5
21	44677.3	273.6	210	268.1	197.1	233.8	782	1.1	269.4	217.7
22	45364.6	272.8	212.8	268	193.3	235	787.4	1.1	269.1	222.5
23	46963.8	282.6	214.6	278.4	199.4	240.3	803.3	1.1	278.1	220.4
24	52911.4	276.3	257.4	282.1	238.9	262.4	879.2	1.2	282.5	272.1
25	53332.2	286.6	238.7	286	223.5	256	848.7	1.1	283.1	245.3

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	28658	212.9	172.9	207.2	163.6	187	615.5	1.1	206.2	172.6
2	29569.8	212.2	182.5	213.7	173.8	191.9	634.9	1.1	215	190.9
3	29583.8	209.9	180.4	207.2	171.2	189.9	620.6	1	205.1	184.8
4	32473.5	229.4	181.6	229.2	172.4	198.4	664.6	1.1	230.1	191
5	32782.1	226.1	185.5	226.2	174.9	200.1	656.9	1	227	188.2
6	32992.5	212.2	207.1	215.6	193.3	205.7	686.8	1.1	217.7	215.7
7	33146.8	224.9	189.3	223	176.7	200.7	668.2	1.1	224.4	195.6
8	33735.9	231.8	186.6	229.2	174.1	202.6	679.8	1.1	229.4	196
9	34044.5	227.9	191.7	222.1	179.3	204.4	674.8	1.1	222.5	197.8
10	35517.4	235.6	195.6	230	182.6	208.6	695.7	1.1	227	201.5
11	36317	240.3	198	242.1	184.2	212.9	712.7	1.1	241.6	208.8
12	36331	225.3	210.7	232.9	198.6	213.6	715.1	1.1	235	214.1
13	36485.3	232.8	200.6	228.2	189.9	211.4	690.3	1	227.2	202.9

14	36892.1	244.8	193.5	243.4	177.6	211.9	709.4	1.1	242.2	197.8
15	37635.5	244.3	197.9	243.4	184.5	215.9	719.2	1.1	244.6	208.5
16	37747.8	235.9	206.8	236.2	194.3	216.4	709.4	1.1	237	214.5
17	38154.6	239	205.4	240.2	191	215.9	718.4	1.1	236	209.8
18	39052.3	249.4	200.9	242	182.9	218.5	721.9	1.1	239.9	202.4
19	39304.8	250.2	201.1	248.3	189.3	219.5	729.5	1.1	248.9	207.3
20	40567.3	256.2	206.1	256.2	192.6	224.2	748.1	1.1	255.9	217.1
21	41324.8	249.7	213	256	202	224.6	753.4	1.1	256.4	227.8
22	43569.1	259.8	215	259.3	195.7	230.9	770.7	1.1	258.8	218.3
23	49797.3	279.1	229	277.7	213.1	247.5	823.9	1.1	278.3	234.3
24	49937.6	277.7	230.4	277.5	216.1	247.8	821.9	1.1	278.7	241.7
25	53346.2	286.5	240.4	285.8	222.8	257.2	847.4	1.1	286.7	247

G. woodi 872C 6H 1 20-22 Hole 3

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	25249.3	184.8	176.2	187.3	166.2	175.9	579.9	1.1	190.3	181.7
2	30776.1	210.5	187.5	214.5	169.6	195	643.7	1.1	213.7	195
3	30888.4	222.8	177.2	221.8	164.7	193.8	635.6	1	221.2	176.4
4	31014.6	227.9	174	224.8	149.9	193.7	647.5	1.1	226.1	173.2
5	33623.7	227.8	190.4	229.9	180.7	203.4	675.2	1.1	230.1	199.1
6	33637.7	229.8	189.8	227.8	179.2	204.4	677.7	1.1	227.4	195.5
7	33764	223	193.5	218.2	182.3	203.9	662.8	1	217.3	193.9
8	34661.7	229.7	194.4	232.2	186	206.7	678.9	1.1	232.7	202.2
9	35307	227	199.4	225.8	190.3	208.1	684.4	1.1	224	207.1
10	35447.3	230	197.5	236	185.7	208.4	693	1.1	236.3	209.9
11	35601.6	232.1	197.9	233.3	186.3	208.7	698.3	1.1	234.4	209.4
12	35854.1	235.5	197.9	237.4	186	211.3	700.9	1.1	237.3	210.7
13	35924.2	232.3	197.8	235.1	186.4	210.2	694	1.1	235.4	208

14	36345	245	194.5	241.1	180.2	213.3	707.8	1.1	242.6	201.3
15	37256.8	243.7	196	244	188.9	214	707.1	1.1	245.3	203.2
16	37944.1	244.8	198.5	244.6	184.8	216.1	713.3	1.1	245.2	204.8
17	38771.8	242.3	205.8	239.3	190.9	217.8	729.8	1.1	238.7	214.8
18	39262.7	252.7	199.1	253.6	187.6	218.8	728.5	1.1	253.5	208.7
19	39374.9	245	205.5	240.8	187.3	219.7	722.2	1.1	239.8	208
20	40483.1	240	216.9	243.9	206.3	222.4	738	1.1	245.9	227.1
21	43316.6	270.3	205.1	269.1	191.7	229.5	771.6	1.1	268.1	216.3
22	44004	260.1	216.4	256.4	199.1	232.2	766.4	1.1	254.8	217.5
23	45196.3	259.7	222.8	256.9	210.6	236.2	822.1	1.2	258.1	229.6
24	48114	271.7	227.8	277.3	218.1	242.8	815.5	1.1	275.9	242.3
25	49138	280.4	224	278.8	209.8	245.6	812.9	1.1	279.6	230.4

G. woodi 872C 6H 1 20-22 Hole 4

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	25109.1	196.3	163.8	193.3	154	174.6	575.5	1	193.9	166
2	27928.6	203.5	178.9	206	169	186	619.5	1.1	206.1	183.7
3	28559.8	211.3	173.4	209.4	166.2	187.2	617.1	1.1	210.1	181.4
4	29163	211	176.7	208.5	164.8	188.7	616.9	1	210.6	180.9
5	30173	217.1	178.9	218.4	164.3	192.3	645.7	1.1	218.9	188.7
6	30383.4	219	177.6	220.8	168.2	191.7	641.8	1.1	222.4	182.7
7	30509.6	218.6	179	218	168.9	192.9	641.3	1.1	217.5	185
8	32333.2	219.4	190.4	221.9	176.1	198.3	678.1	1.1	220.6	199.8
9	32627.8	221.8	188.9	218.8	180.7	199.1	660.5	1.1	218.9	194.5
10	32936.4	237.6	177.6	241.1	164.8	200.7	678.1	1.1	241.3	181
11	33006.5	228	185.5	232.2	178.9	200.6	669.9	1.1	232.3	198.6
12	33385.2	226.7	189.5	230	176.7	201.9	676.9	1.1	228.3	197.3
13	35741.8	232.9	196.2	231.5	186.6	209.2	685.7	1	232.6	198.8

14	37649.6	223.2	216.3	226.7	200.5	215.1	707.2	1.1	228.8	225
15	38042.3	237.4	205.4	233.7	188.3	215.9	712	1.1	227.2	202.9
16	39781.7	234.7	217.9	237.3	201.3	220.9	721.1	1	238.3	220.4
17	39936	248.8	206	249	193.3	220.3	736.5	1.1	247.6	217.7
18	41563.2	247.1	216.2	249	200.8	225.5	752.2	1.1	251.1	221.4
19	41913.9	258.1	207.5	257.2	198.1	226.8	745.8	1.1	258.6	213.8
20	42292.6	260.3	207.9	258.5	184.5	227.1	759.4	1.1	258.6	209.7
21	42545.1	258.2	213.1	256	194.8	229.8	755.3	1.1	253.7	215.1
22	42825.7	254.2	219	251.2	209.4	231.7	754.7	1.1	249.2	223.4
23	44102.2	254.2	223.6	249	207.8	233.7	765.6	1.1	248.7	229
24	54650.8	295.9	237.2	290.2	221	259.7	852.6	1.1	288.5	236.1
25	78202.8	340.1	294.4	337.4	280.9	311.8	1032	1.1	343.6	302

O.universa GLOW 3 BoxTop Hole 1

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	153179	452.2	431.3	451	425.9	438	1388.1	1	451	430.5
2	198782	520.4	486.4	522.3	479.5	499.7	1586.4	1	520.6	489.7
3	208630	525.6	505.8	528.4	498.4	511.7	1621.8	1	522.7	505.8
4	210145	526.4	508.3	525.2	500.7	513.7	1628.6	1	523.8	506.3
5	229376	560.4	521.2	562.4	514.9	536.9	1705.2	1	561.7	523.2
6	231060	547.1	537.7	550.1	529.7	539.1	1732.3	1	547.3	538.3
7	231579	548.3	537.8	548.7	530.5	539.7	1715.2	1	548.4	535.9
8	234468	556.9	536.1	557.8	523	542.9	1719.3	1	555.4	534.2
9	247037	570.5	551.4	571.1	535	557.1	1775.9	1	568.5	549.5
10	252732	577.8	557	579.6	549.7	563.8	1800.8	1	579.3	571
11	257754	581	564.9	586.3	556.9	569.4	1802.9	1	578.6	563.6
12	261737	590.3	564.6	594.7	556.4	573.7	1817.1	1	593.9	562.8
13	268807	597.7	572.6	597.4	562.7	581.4	1840.8	1	597.9	569.8

14	273114	602.8	577	600.4	556.8	586.1	1868.7	1	599.4	571.1
15	273142	594.7	584.8	594.8	578.5	586.3	1857.8	1	594.3	585.3
16	279861	602.9	591.1	603.4	583.4	593.3	1880.8	1	601.3	592.5
17	286426	617.7	590.6	617.1	574.8	600.4	1904.9	1	618.2	595
18	292570	623.5	597.6	620.9	586.3	606.8	1931.5	1	617.9	593.8
19	293033	620.3	601.5	618.9	594.8	607.4	1922.5	1	617.6	600.9
20	295656	616.8	610.3	619.5	601.5	610.2	1944.3	1	620.2	615.9
21	298391	622.2	610.6	625.7	601.6	612.7	1941.2	1	619.8	609.8
22	306485	629.5	620	634.8	611.3	621.2	1977.7	1	632.4	622.9
23	350980	679.4	657.8	678.8	645.1	665	2112.3	1	678.3	653.3
24	353350	688.5	653.6	689.1	648.9	667.3	2110.1	1	688.3	656.1
25	495097	810.2	778.2	815.3	759.8	790.4	2513.3	1	812.1	782.6

O.universa GLOW 3 BoxTop Hole 2

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	139867	429.1	415	427.1	406.2	418.6	1341.7	1	427.2	417.4
2	172299	488.3	449.4	487.1	444.7	464.7	1490.9	1	487.2	451
3	180098	498.6	460.4	494.7	442.3	475.3	1520	1	494.6	460.4
4	186649	495.1	480	494.4	472	483.8	1532	1	493.9	477.1
5	194252	498.7	496.1	503.9	483.3	493.8	1578.1	1	499.9	494.4
6	213862	524.5	519.2	525.7	510.2	518.4	1641.8	1	522.3	517.1
7	217018	528.5	523	535.6	508.5	522.5	1672.6	1	535	526.5
8	230190	557.8	525.8	565.5	517.6	537.8	1749.5	1.1	551.8	522.6
9	236614	564.4	533.8	566.8	523.7	545.4	1739.9	1	563.9	531.5
10	246307	576.1	544.4	575.4	535	556.4	1761.4	1	574	548
11	255972	580	562.1	579.5	545.4	567.3	1808.5	1	579.2	556.2
12	265174	587.6	574.8	599.5	563.2	577.3	1843	1	584.1	570.5
13	275007	603.1	580.6	601.5	571.4	588.1	1863.5	1	601.8	577.9

14	276256	602.1	584.3	611.1	574.5	589.6	1878.8	1	606.1	583.8
15	295081	628.9	597.5	629.5	582.9	609.3	1940	1	629.3	596.5
16	295740	623.7	603.8	624.6	597.5	610.3	1932.6	1	625.1	606
17	296006	619.7	608.2	628.1	599.9	610.6	1977.6	1.1	629.2	618.9
18	296539	620.7	608.4	623.1	601.6	611	1941.7	1	622.1	610
19	297606	625.1	606.2	623.1	598.1	612.2	1934.4	1	623.1	603.9
20	316865	645.8	624.9	644.2	612.4	631.4	2003.9	1	646.9	625.9
21	324398	659.6	626.4	658.3	614.4	639.2	2027.4	1	657.2	630.1
22	341834	680.6	640.3	678	609.3	655.8	2104.1	1	676.1	633.3
23	353519	682.1	659.9	686.5	653	667.5	2123.8	1	683.2	661.3
24	379259	709.2	681.1	725.7	668.8	691.3	2275.6	1.1	726	707.2
25	401633	735.3	695.6	732.2	683.4	711.6	2253.5	1	729.6	691.4

O.universa GLOW 3 BoxTop Hole 3

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	149813	443.6	430.1	442.9	421.1	433.2	1382.3	1	441.8	431.5
2	175763	490.7	456.2	490.9	432.4	469.4	1521.2	1	492.2	455.7
3	218912	533	523	533.1	515.4	524.5	1659.5	1	531.9	522.2
4	229124	544.8	535.5	545	527.2	536.6	1703.4	1	545.8	538.5
5	236951	560.4	538.4	559.6	526.6	545.8	1731	1	560	531.9
6	241510	563.6	545.6	565.1	539.1	551.1	1746.3	1	561.7	547.7
7	243474	564.1	549.5	564.1	542.2	553.5	1751.6	1	564.8	548.9
8	251554	574	558	575.2	551.8	562.5	1781.7	1	575.2	558.9
9	253728	577.4	559.5	578.2	551.6	564.9	1789.5	1	577.7	565.4
10	277294	604.5	584.1	603	576.5	590.8	1866.5	1	602.5	580.7
11	291027	623.6	594.8	623.5	574	604.9	1933.8	1	623	606.5
12	291419	616.4	602	617.2	594.8	605.5	1920.7	1	616	601.7
13	304297	643.3	602.7	639.7	580.3	618.6	1970.2	1	638.8	598.4

14	308659	637.3	616.7	637.2	608.6	623.3	1971.5	1	635.2	615
15	313064	637.3	625.6	651.8	615.3	627.8	2002.4	1	636.5	625.3
16	326165	656.7	633.1	655.9	622.5	641.7	2047.6	1	657.2	640.6
17	333965	658.6	645.7	659.8	637.6	648.7	2055.8	1	660.4	650.5
18	341357	670.2	648.5	670.9	641.5	655.7	2074.4	1	669.2	649.1
19	342718	673.4	648.1	675.3	639.3	657.2	2088.1	1	672	648.7
20	439703	749.6	746.9	753	737.5	744.7	2358.4	1	745	744.7
21	240247	561.2	545.1	560.9	530.8	549.8	1741.5	1	562.1	544.7
22	249576	571.9	555.7	573.7	549.4	560.1	1774.5	1	573.7	558.8
23	265721	589.2	574.2	589.9	567.8	578.2	1829.3	1	588.4	572.8
24	287632	612.7	597.8	611.9	580.3	601.5	1917	1	609.7	596.3
25	427036	745.6	729.3	745.5	722.8	733.8	2319	1	745.3	729.3

O.universa GLOW 3 BoxTop Hole 4

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	163490	466.4	446.5	477.3	433.5	453	1491.9	1.1	466.9	447.1
2	172495	472.2	465.3	488	456	465	1511.6	1.1	468.2	463
3	173393	475.5	464.5	489.7	452.7	466.5	1504.5	1	484.2	461.1
4	175174	479.8	464.9	481.8	453.3	468.9	1514.7	1	482.5	464
5	176044	483.5	463.7	485.6	458.8	469.9	1490.5	1	485.6	465.6
6	179902	487.7	469.7	488.3	461.3	475.2	1511.3	1	487.1	473.1
7	179972	487.9	469.7	487.3	460.4	475.2	1512	1	486.8	469.5
8	183577	491.4	475.9	500.1	464	480	1578.1	1.1	506.6	477
9	200494	514	496.7	517.1	488.2	501.9	1593.3	1	516.5	495.7
10	208784	523.6	507.8	527.3	497.3	512.1	1643.6	1	521.5	516.2
11	225028	540.7	530	564.3	522.4	531.7	1730.6	1.1	538.4	530.7
12	245550	565.3	553.3	583.9	544	555.7	1793.9	1	569.7	556.7
13	272735	600.2	578.6	599.4	569.4	585.7	1860.9	1	600.8	578.7

14	283368	613.2	588.8	635.8	578	597.5	1934.9	1.1	630.1	590.5
15	307284	632.2	618.9	638.3	611.1	622.3	1986.7	1	630.1	616.9
16	319881	645.8	630.7	648.2	621.6	634.7	2035	1	646.5	632.5
17	322574	653.3	628.8	666.3	620.4	637.3	2051.6	1	651.4	628.1
18	348581	684.6	649.2	682.5	635.7	663	2105.2	1	681.1	649.2
19	438876	762.3	733	762.3	725.7	743.9	2371.9	1	761.4	734.7
20	545063	871.3	796.7	884.6	788.8	829.5	2746.6	1.1	884.6	795.2
21	123441	398.6	394.4	398.9	388.4	393	1245.7	1	398.5	392.7
22	132475	420.3	401.4	423.8	393.2	407	1300.3	1	415.9	401.7
23	170377	473.8	457.9	473.9	451.7	462.3	1466.9	1	473.9	457.6
24	208503	518.7	511.9	531	500.1	511.6	1662.2	1.1	514	510.2
25	256000	581.9	560.3	580.3	541.1	567.3	1810.5	1	580	560.7

G.calida 872C 3H 1 59-61 Hole 1

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	61987.1	299.6	266.9	304.8	231.2	276	933.4	1.1	285.2	271.7
2	67640.2	352.4	251.6	357.8	209.4	283.8	1060.6	1.3	360.1	280.9
3	72213.1	345.6	270.6	354.9	232.9	296.6	1027.5	1.2	352.3	292.5
4	72479.6	336.3	278.2	347.4	248	298.4	1023.8	1.2	343.7	296.4
5	77122.7	379.2	262.1	374.6	228.5	305.4	1079	1.2	376.3	277.4
6	86030.1	386.9	288.3	388	258	322.8	1159.9	1.2	390.3	313.4
7	88022	369.1	306.9	380.9	272.8	329.2	1121.7	1.1	380.3	334.2
8	90476.8	388.9	302.6	384.9	254.9	331.4	1194.1	1.3	386	324.9
9	97041.6	392.9	320	403.4	266.2	344.6	1194.1	1.2	398.8	340.9
10	97125.8	420.7	298.7	421.7	245.4	346.3	1194	1.2	420.1	304.8
11	97644.8	414	305.7	414	266.9	344.7	1226.8	1.2	410.4	322.2
12	100086	411.2	315.3	414.4	274	348.8	1241.2	1.2	410.8	338
13	101909	415.2	318.4	420.1	272.6	352.2	1245.3	1.2	422	340.3

14	105388	438.3	309.6	435.5	256.4	358.7	1285.6	1.2	435.6	327.5
15	106033	424.9	323.8	427	256.4	358.4	1311.7	1.3	427.9	354.2
16	106202	422.5	327.4	433.1	276.2	359.8	1319.5	1.3	432.7	363.6
17	114408	421.6	351.7	432.5	310	375.6	1335.4	1.2	410.5	348.7
18	114436	447.9	333.4	458.2	283.8	371.8	1363.5	1.3	456.2	368.6
19	114744	413.4	362.8	428.8	314.8	374.9	1402.7	1.4	437.1	391.3
20	124409	483.1	334.6	486.4	273.4	386.9	1457.9	1.4	484.4	366
21	132685	470.5	366.8	475.4	300.5	401.9	1471.2	1.3	471.4	387.1
22	133204	449.8	383.3	468.2	335.1	405.7	1429.4	1.2	470.4	418.2
23	146166	500.3	379.3	527.1	333.6	423.2	1558	1.3	518.9	420.4
24	189805	567.6	436.8	587.3	375.4	481.6	1762.7	1.3	592.3	477.7
25	207171	611	440	602.2	379.7	502.8	1816.6	1.3	596.2	452.1

G.calida 872C 3H 1 59-61 Hole 2

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	42853.7	264.6	210.2	268.1	179.3	227.7	804	1.2	268.5	232
2	50007.7	278.6	232.4	280.1	213.5	246.8	838.2	1.1	280.6	237.4
3	52434.5	271.2	249.9	285.8	228.3	253.5	935.2	1.3	288.4	262.2
4	52995.6	299.2	229.4	295.3	216.4	254.5	868.6	1.1	295.4	241.9
5	59237.8	315.6	240.8	319.1	221	269.2	906.7	1.1	319.1	249.5
6	62828.8	332	244.7	324.7	217.4	276.3	964.9	1.2	323.7	255.5
7	63249.6	329.6	248.5	326.6	221	276.9	977	1.2	326.7	267.3
8	64035.1	317.4	261.5	320.5	237	279.5	962.9	1.2	322.3	275
9	64189.4	335.8	248.4	333.4	224.8	278.3	1033.5	1.3	331.2	269
10	69127.1	327.1	273.9	335.4	227.8	290.7	1012.6	1.2	339.9	291.3
11	70501.8	349.9	262.3	349.8	246.5	292.3	1028.9	1.2	351.7	277
12	72802.3	358.7	261.4	361.9	244.2	297.7	1041.6	1.2	364.4	285.1
13	77543.5	361.1	278.8	368.2	248.1	306.6	1079.5	1.2	371.5	305.8

14	82004.2	360.6	293.2	358.4	254.2	317.2	1097.5	1.2	356.3	288.3
15	83449.1	365	299.5	382.2	258	318.4	1254.9	1.5	382.8	328.8
16	84192.5	389.2	280.7	384.2	210.1	320	1175.6	1.3	371.9	283.4
17	86352.7	356.3	313.3	366.9	255.6	325.9	1119.4	1.2	351.5	314.5
18	91430.7	409	289.5	408.2	247.2	332.1	1206.5	1.3	407.3	307.3
19	95414.4	411	300.8	406.6	260.2	341	1191.2	1.2	407.9	310.9
20	101643	435.9	300.4	423.6	251.6	350.6	1237.9	1.2	426.4	309.9
21	111658	404	360.6	417.8	296.1	370	1357.7	1.3	417.1	366.3
22	126864	484.3	344.2	486.9	251.6	388.4	1522.9	1.5	486.6	381.3
23	130876	485.2	351.1	488.6	319	398.3	1437.1	1.3	489	389.4
24	133793	477.2	364.3	470.1	305.5	404	1521.8	1.4	467.8	385.3
25	166505	550.8	389.7	550.2	308.2	450.7	1708.1	1.4	549.9	413.8

G.calida 872C 3H 1 59-61 Hole 3

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	28026.8	217.4	167.6	217.2	141.2	183.5	647.9	1.2	216.6	181.7
2	46837.5	257.4	236.2	270.1	207.8	238.8	832.7	1.2	273.6	257
3	52420.4	289.1	237.6	289.6	141.3	247.3	987.9	1.5	268.6	237.7
4	59728.7	313.2	245.4	314.6	218.8	270	926.4	1.1	313.4	252.2
5	62562.3	321	253	327.2	239.8	275.5	969.1	1.2	331.2	272.5
6	63586.3	327.2	254.1	318.6	233.1	277.5	979.7	1.2	321.5	270.7
7	67528	343.6	253.8	342.1	216.7	286.4	1009.7	1.2	341	273.7
8	71287.3	323.3	285.9	333.3	225.9	295.5	1017.7	1.2	312.4	286.4
9	75411.4	358.7	270.8	351.9	241.8	303.3	1071.7	1.2	349.4	277
10	76463.4	365	271.5	369.8	225.1	304.8	1076.6	1.2	366.4	292.6
11	76477.4	365	272.5	368.8	238.3	304.4	1080.9	1.2	370.4	296.5
12	76786	351.5	282.2	358.5	243.6	306.8	1065	1.2	355.7	302.9
13	79156.7	377	274.2	375.4	254.3	309.2	1099.5	1.2	379.9	299.8

14	81653.6	348.7	306.9	350.4	279.6	315.7	1120.3	1.2	355.9	318.4
15	84683.5	393.9	279.7	392.3	258.5	319.4	1137	1.2	394.9	297.8
16	95765.1	410.7	303.7	418.3	243.1	341	1229.6	1.3	415.2	335.4
17	95989.6	413.3	299	404.7	254.7	342.5	1184.1	1.2	402.1	311.8
18	97644.8	392.6	320.5	404.8	288.7	346.6	1199	1.2	406	351.5
19	100408	429.5	303.9	426.8	269.1	348.3	1248.9	1.2	427.1	344.7
20	108937	423.8	343	429.3	254.2	357.1	1431.9	1.5	442.1	377.3
21	115179	442.4	336.9	441.9	258	375.7	1346.9	1.3	444	360.4
22	117690	452.4	337.9	459.1	282.1	377.6	1370.5	1.3	461.6	370.5
23	128856	502.2	337.4	501.6	236	394.9	1490	1.4	500.3	368.8
24	145086	488.1	388	498.1	323.3	422.9	1543.1	1.3	493.6	415.3
25	149953	522.9	371.3	507.1	273.4	425.7	1599.2	1.4	500.4	374.8

G.calida 872C 3H 1 59-61 Hole 4

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	42966	271.5	205.1	274.7	175.6	227.5	806.9	1.2	274	213.8
2	46991.8	285	213.5	284.4	185	238.1	856.6	1.2	285.1	230.8
3	47005.9	274.8	221.9	285.8	194.2	240	832.3	1.2	285.3	237.5
4	49446.6	300.8	212	301.1	194.5	244.6	860	1.2	299.9	232.6
5	56712.8	300.4	244.3	307.1	201.2	263.3	906.2	1.2	302.2	253.8
6	60598.4	335.2	235.6	335	204.6	271.9	968.4	1.2	338.6	251.3
7	60612.4	330	238.5	323.9	213.5	270.2	952.9	1.2	325.3	252.1
8	61762.7	301.6	264	303.2	242.9	275.7	929.4	1.1	302	279.4
9	62786.7	321	253.1	327.6	212.8	276.8	956.7	1.2	327.2	270.2
10	65269.5	327.4	258.2	324.7	220.4	281.8	1007.1	1.2	323.2	271.7
11	70010.8	356.9	254.2	342.5	212	290.8	1029.6	1.2	353.5	259
12	70670.1	353.3	259.1	358.5	238.9	292.6	1025.7	1.2	361.1	284.4
13	73307.2	340.6	278.8	353.3	263.7	299.6	1030.2	1.2	352.9	305.5

14	74050.7	356.8	268.3	355.8	238.2	300	1063.2	1.2	352.1	282.8
15	74485.6	347.2	280.4	346.2	230	301.1	1066.4	1.2	340.8	298.4
16	75537.6	344.6	282.9	349.9	258.7	304.6	1054.1	1.2	351	305.7
17	77445.3	340.8	292.7	346.1	269.7	308.6	1050.2	1.1	346.6	302.7
18	86240.5	394.4	283.5	394.4	228.6	322.9	1180.6	1.3	393.8	307.6
19	90673.2	384.3	303.7	393.3	278.4	333.6	1154.8	1.2	393.4	322.6
20	93170.1	369.3	331.5	376	224.5	332.4	1334.8	1.5	389.7	352.7
21	96171.9	416.2	299.1	418.1	251	341.7	1229.4	1.3	416	325.8
22	121043	447.6	352.9	455.3	275	383.3	1420.5	1.3	454.2	374.7
23	126106	474.9	349.8	481.1	259.8	391.2	1500.6	1.4	486	395.3

G.siphonifera 872C 3H 3 119-121 Hole 1

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	48240.3	281.2	220.3	277.3	182.3	242.4	835.8	1.2	279.5	226
2	60640.5	320.4	242.1	317.3	226.3	272.4	912.7	1.1	317.2	248.6
3	69295.4	336.9	266.3	344.3	235.8	292	1013	1.2	344.8	284.6
4	77782	352	284.6	359.6	270.1	309.1	1052.5	1.1	356	293.3
5	89677.2	410.6	280.5	414.5	258.5	329.9	1170.4	1.2	422.1	294.6
6	89971.8	387.9	297.7	389.5	275.4	332.1	1129.5	1.1	390.1	314.2
7	105332	428.8	315.4	422.7	289.1	359	1240.7	1.2	419.7	322.2
8	106103	433.2	316.1	429.7	286.6	359.9	1247.1	1.2	430.8	340.7
9	126850	478.7	340.3	473.7	312.8	394.4	1359.7	1.2	474.8	354.6
10	128856	472.7	351.4	473.1	299.9	397.9	1393.6	1.2	462.4	359.2
11	134327	503.5	344.5	489.3	236.1	402.2	1524.7	1.4	490	340.9
12	135715	468	372.9	466.6	348.5	409.2	1382	1.1	465.6	392.5
13	136557	469.3	379.5	482	301.5	408.9	1453.5	1.2	472	385.6
14	146222	525.3	360.6	520.6	308.4	420.2	1541.9	1.3	520.7	388.7
15	153292	499.8	395.3	486.7	313.2	434.6	1554.1	1.3	485.5	393.3

16	161456	519.5	398.2	513.5	360.8	446.5	1500.7	1.1	512.2	401.4
17	179088	550.9	415.5	547.3	385.6	470.9	1574.4	1.1	549	420.8
18	185849	557.1	433.8	555.4	357.5	476.6	1712.7	1.3	555.9	459.7
19	186677	563.7	424.6	558	388.6	480.1	1622.8	1.1	560.1	435.3
20	192582	582.6	423.9	582	403.4	486.8	1662.5	1.1	580.6	441.8
21	211014	597.2	452.9	594.8	397	510.8	1772.6	1.2	596.4	467.7
22	213946	610.4	449.3	604.7	411.6	513.9	1742.2	1.1	604.7	464.9
23	216850	589.2	476	598.4	449.2	518.4	1811.3	1.2	600.9	511.2
24	218673	593	474	594.4	435.6	521.3	1769.9	1.1	596.1	495.8
25	253531	670.3	484.2	661.2	426.8	559.7	1935.5	1.2	661.9	485.2

G.siphonifera 872C 3H 3 119-121 Hole 2

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	66377.7	328.9	261.5	334.3	246.5	284.3	980.4	1.2	335.5	284.2
2	68916.7	338.9	261.1	335.9	223.9	290.9	991	1.1	335.1	271.3
3	75579.7	347.4	281.8	357.8	260.9	304	1063.2	1.2	358.9	310.4
4	82340.9	371.3	285.5	370.9	245.3	317.8	1083.4	1.1	373.9	292.8
5	93548.8	390.8	307	385.6	266.5	339.4	1165.8	1.2	386.1	318.1
6	108516	419	333.9	415.8	282.4	364.6	1269.6	1.2	416.1	352.7
7	109891	427.6	332.1	428	297	366.7	1269.9	1.2	427	352.1
8	119079	459.6	332.8	452.5	294.2	382	1313.5	1.2	452.7	341.6
9	128098	477.7	346.5	479	299.8	395.5	1427.2	1.3	479.4	370.9
10	129922	487.9	342.9	485.7	282.8	398	1441.4	1.3	485.1	367.7
11	130090	474.7	350.7	468.2	309	400.2	1337.5	1.1	469.1	351
12	133373	479.5	358.3	475.7	318.4	404.4	1410.2	1.2	470.4	377.4
13	143332	501.6	370.5	493.2	330.9	421.4	1446.5	1.2	489.4	374.4
14	143388	513	361.1	503.9	307.1	417.8	1484.8	1.2	501.9	384.6
15	143991	487.7	379.6	488.3	326.2	421.4	1443.8	1.2	481.4	404.8

16	146979	488.4	389.7	484.7	318.4	424.6	1509.7	1.2	492.8	412.8
17	153684	501.5	394.5	495.1	323.9	435.4	1477.2	1.1	492.6	400.3
18	157191	507.5	402.3	504.7	341.8	438.8	1568.2	1.2	517.2	430.8
19	159576	531	384.9	522.2	340.1	443.1	1498.1	1.1	522.2	387.5
20	161470	517.3	405	521.4	340.1	444.6	1538.3	1.2	516.3	422.6
21	183100	545.4	430.5	542.6	394.7	476.2	1624.7	1.1	541.2	441.6
22	186663	588.7	409	578	350.9	477.3	1692.4	1.2	578	431.6
23	187056	540.6	443.4	543.6	428.8	482.1	1607.6	1.1	542	462
24	209682	614.3	440.4	604.7	390.3	506.6	1771.7	1.2	607.1	467.2
25	278500	672.5	535.1	663.5	447.3	586.9	2053	1.2	681	546.9

G.siphonifera 872C 3H 3 119-121 Hole 3

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	61145.5	332.7	237.4	325.9	202.8	272.3	949	1.2	328.4	249.9
2	89565	383.1	301.2	378.7	251.9	331.3	1149.4	1.2	378.9	308.1
3	90757.3	389.6	297.9	387.2	270.9	334.5	1112.4	1.1	389.2	302.4
4	99300	416.2	305.7	409.9	280.3	348.6	1178.6	1.1	408.7	305.9
5	104476	417.4	320.1	413.4	277.2	358.8	1203.1	1.1	412.6	316.7
6	110368	444.8	319.7	438.6	274.9	366.5	1297.6	1.2	436.1	333.4
7	110634	435.8	326.3	425.2	272.7	368.5	1273.3	1.2	426	335.5
8	117746	446.3	340	441.8	295	380.3	1320.5	1.2	439	361.1
9	118784	437.7	349.4	448	307.5	382.8	1319.4	1.2	448.1	364.6
10	118840	450.6	340.1	444.6	269.1	381.3	1367.1	1.3	443.7	357.9
11	129866	473.5	351.3	467.3	297.4	399.9	1357	1.1	466.1	352.4
12	131521	483.9	348.7	474.4	320.1	402	1381.6	1.2	472.5	357.3
13	140358	494.1	368.4	486.9	273.8	412.3	1507.7	1.3	484.7	389.3
14	140527	493.1	371.6	479.7	292.1	418.2	1474.7	1.2	480.4	382.7
15	146432	505.7	371.4	504.2	334.3	424	1484	1.2	503.1	390.8

16	152029	495.9	393.5	489	344.6	433.8	1477.1	1.1	486.9	404.4
17	155606	508.5	393.8	504.6	336.5	438.2	1542.8	1.2	500.5	411.4
18	160937	530.7	388.1	524.9	364.9	445.6	1508.4	1.1	524.9	397.7
19	161820	520.4	400.8	519.1	364.9	446.4	1541.7	1.2	520.6	426.4
20	162451	536.3	389.9	524.8	341.7	446.3	1557.6	1.2	523	411.1
21	180407	567.3	411.8	562.1	354.1	469.5	1678.3	1.2	558.9	439.5
22	182202	559.5	416.6	558.1	366.5	474.6	1599.5	1.1	557.4	416.1
23	226613	620.8	469	618	417.2	528.9	1840.1	1.2	618.3	493.7
24	233641	624.2	481.7	617.8	423	536.9	1875.8	1.2	618.7	496.5
25	291041	710	526.5	702.9	457.3	600	2096.5	1.2	712.8	548.3

G.siphonifera 872C 3H 3 119-121 Hole 4

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	71287.3	346.2	265	343.8	236	294.9	1023.2	1.2	341.1	281
2	75102.8	349.5	277.5	346.4	237.2	303.1	1067	1.2	351.3	296.1
3	77571.6	374.7	266.8	377.2	257.7	307.1	1069.5	1.2	379.7	286.9
4	97855.2	426.6	296.3	418.3	248.6	343.8	1227.8	1.2	416.7	309.7
5	100422	395.4	327.7	396.4	273.6	351.5	1206.6	1.2	393.7	342.9
6	116035	447.7	332.2	442.1	301.1	377.5	1273.4	1.1	441.2	342.8
7	126780	429	380.7	451.3	316.5	396.1	1350.5	1.1	446.6	404.3
8	129024	465.7	356.2	464.3	331.3	398.5	1373	1.2	461.9	368.8
9	129824	440.7	382.5	455.4	294	400	1441.9	1.3	423.1	381.5
10	134817	450.2	387.2	451.3	296.5	407.4	1460.4	1.3	458.2	399
11	137399	493.7	357.8	483.1	310	410.1	1436	1.2	483.2	368.9
12	144090	501.4	369.7	497.2	312.3	420.5	1455.9	1.2	498	394.1
13	146516	507.7	370.5	506.9	345.9	424.2	1452.4	1.1	503.3	381.6
14	155045	518.4	386.7	512.5	308.2	435.6	1555.5	1.2	517.5	414.6
15	165243	549.2	387.9	543.5	316.4	449	1639.2	1.3	544.9	407.4

16	183156	542.6	432.7	534.4	371.4	477	1584.6	1.1	534.3	435.6
17	191867	580	424.6	570.8	350.9	485.9	1676.6	1.2	569.8	425.5
18	200213	598.9	428.1	591.6	379.2	496.9	1696.2	1.1	591.1	433.2
19	202570	581.4	451.8	580.3	400.6	498.8	1747.7	1.2	586.9	482
20	208714	603	446.8	599.8	400.5	506.7	1778.3	1.2	599.3	471.9
21	210972	575.2	478.3	596	355.3	507.3	1905.8	1.4	569.6	496.3
22	218393	620.7	455.4	615.1	380.9	516.9	1935.5	1.4	614	489.9
23	218954	598.9	468.8	589.2	392.5	521.6	1793.6	1.2	576.5	457.3
24	232981	647.6	462.8	636.4	368.3	534.6	1873.2	1.2	636.4	472
25	242800	634.2	491.7	636.5	466.4	548.5	1866.2	1.1	634.3	520.4

G.tenella GLOW 3 BoxTop Hole 1

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	20704.5	176.2	151.7	176.7	143.1	158.8	531.1	1.1	181.6	158.3
2	25445.7	183.8	177.3	192.8	161.6	176.5	602.3	1.1	186.2	179.4
3	25642.1	208.6	158	206.8	138.6	175.7	606.7	1.1	202.6	163.3
4	27269.3	199.8	175.7	196.1	164.2	182	613.8	1.1	200	182
5	28714.1	207.5	178.8	222.3	160.8	187	655.6	1.2	221.3	183.5
6	29191	201	190	215.2	169.7	186.8	670	1.2	210.9	188.3
7	29850.3	208.4	185.2	210.1	177.5	190.7	639.3	1.1	204.1	188.8
8	31126.8	201.7	199.5	209.5	181.2	195.2	676.9	1.2	202.6	199.1
9	33245	219.5	195.6	233.2	188.2	201.6	678.6	1.1	235.9	201.2
10	33427.3	225	191.7	227.5	177.6	201.9	673.3	1.1	228.8	195
11	34086.6	220.2	199.6	216.7	182.8	203.8	681.2	1.1	217.7	203.7
12	34269	232.8	190.4	234.6	178.4	204	711.6	1.2	238.8	205.4
13	34942.3	228.5	196.9	232.8	187.3	206.5	696.5	1.1	233.3	206.7
14	35545.5	230.8	200.4	228.2	183.7	207.4	711.8	1.1	233.6	209.6
15	35587.5	240	194.2	240	169.2	206.7	762.5	1.3	237.6	206.3

16	35713.8	216.5	213	223.3	185.5	209.2	702.2	1.1	221.1	212.3
17	36064.5	230.5	202.5	248.7	186	209.9	732.1	1.2	252.3	214.5
18	36751.8	228.3	207.9	270.1	188.9	211.8	817.6	1.4	246	207.5
19	37495.3	245.6	197.6	240	173.2	213.5	728.1	1.1	234	201.4
20	38884	267.1	189.1	289.3	172.2	216.2	826.2	1.4	288	202
21	39206.6	254.1	199.1	259.7	171.8	218	772.7	1.2	242.8	197.2
22	39599.4	237.5	215.7	248.7	199.4	220.2	749.2	1.1	249	229.1
23	41437	248	214.8	248.6	193.8	226.3	750.1	1.1	250.6	224.7
24	43765.5	247.2	229.5	268.1	217.9	231.6	857.3	1.3	265.2	233.8
25	59911.1	298.5	260	322	241	270.9	977.5	1.3	310.3	270.1

G.tenella GLOW 3 BoxTop Hole 2

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	17043.3	153	144	161.1	134	143.5	519.5	1.3	168.3	146.1
2	21995	189.9	153.1	221	145.7	163.8	677	1.7	221.1	165
3	24533.9	194.5	162.2	189.1	146.8	172.9	572.8	1.1	187.8	162.6
4	26848.5	190.9	181.4	202	165	181.6	638.4	1.2	210.7	183.3
5	27241.2	208.7	167.1	209.4	149.1	183	618.9	1.1	212.5	175.2
6	27409.6	200.3	176.4	201.2	165.8	183	606.6	1.1	204.3	180.7
7	27928.6	201.5	177.9	198.5	168.9	185.3	626.4	1.1	201.5	179.6
8	28826.3	196.2	189.8	206	172.5	187.9	648	1.2	207.6	206.5
9	29078.8	201.4	186.5	212	174.6	188.4	652.7	1.2	208.9	194.7
10	29429.5	199.9	189.8	200.3	178.4	189.6	625.3	1.1	209.4	189.3
11	29794.2	203.7	190	220.3	172.9	190.7	744	1.5	213.1	190.8
12	30411.4	211.4	186.4	234.6	171.6	192.6	669.9	1.2	239.3	196.2
13	30425.5	204.1	192.4	213.7	172.4	192.6	655.1	1.1	214.6	199.3
14	30874.3	202.3	197.4	209.4	183.7	194	680.4	1.2	213.6	206
15	31828.2	224.3	182.5	231	170.9	197.4	662.8	1.1	233.4	198

16	35405.2	231.5	198.7	247.9	182.8	208	786.5	1.4	249.6	209.9
17	37355	229.4	212.3	240	194.2	212.7	844.9	1.5	224.7	221.1
18	37733.7	246.3	198.7	246.4	176.1	213.7	758.3	1.2	246	202.5
19	38322.9	226.7	219.4	228.8	205.7	215.7	734.4	1.1	236	220.5
20	38701.6	252.7	197.4	244.6	165.8	217.8	758.6	1.2	255.2	200.9
21	38799.8	227.8	220.3	251.1	196.1	218.6	781.9	1.3	230.7	227.3
22	40693.5	248.9	211.2	256	189.5	222.5	762.6	1.1	256.7	228.3
23	43260.5	252.8	221.2	261.6	203.7	230.6	789.1	1.1	261.2	234.1
24	43863.7	267	211.9	282.1	191	231.1	894.1	1.5	279.2	217.4
25	64077.2	310.4	267	312.7	249.6	280.1	1057.9	1.4	315.9	285.6

G.tenella GLOW 3 BoxTop Hole 3

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	21714.4	178.9	156.4	180.7	148.5	163.5	542.9	1.1	185	165.4
2	21826.7	172.1	162.8	188.6	149.2	164	554	1.1	185.6	167.6
3	25277.4	190.3	170.3	186.6	157.5	175.1	581.3	1.1	190.5	171.3
4	25922.7	201.8	164.7	199.1	152.8	177.7	594.1	1.1	195.3	165.2
5	26441.7	192.8	177.2	196	170.4	178.7	603.3	1.1	195.1	180.7
6	26764.3	206.7	167	214.5	143.4	183.2	679.8	1.4	221.2	160.5
7	27157.1	199.9	175.3	206.4	167.7	182.2	614.7	1.1	203.9	184.6
8	27970.7	196.5	183.8	207.4	165.2	184.7	627.7	1.1	206.9	196
9	30173	209.2	185.2	215.1	172.7	192.4	633.3	1.1	214.1	195.3
10	31477.5	219.7	188.9	238.4	178.7	194.8	746.9	1.4	252.4	191.8
11	32431.4	237.8	175.3	232.3	164.5	198.7	690.6	1.2	233	186.1
12	33455.4	225.3	193.4	230	171.8	201.2	732.7	1.3	233	202.4
13	36274.9	245	191	247.4	164.5	209.5	727.7	1.2	237.3	195.2
14	36317	220.7	212.7	229.9	197.1	210.4	729.6	1.2	233.8	217.7
15	36822	249.2	190.4	247.9	170.8	210.5	754	1.2	248.4	190.7

16	37004.3	238.6	199.5	237	174.3	212.8	733.2	1.2	231.3	207
17	37579.4	230.9	209.7	230.4	195.3	214.4	710.4	1.1	233.4	212.9
18	37719.7	256	190.9	254.8	167.5	212.8	740.9	1.2	256.1	199.5
19	42362.8	258.2	212	263.5	188.1	227	786.4	1.2	262.3	224.6
20	45603.1	277.6	212.6	278.4	179	235.4	859.7	1.3	270.3	217.4
21	51059.8	291.6	226.7	293.7	187.3	248.4	866.3	1.2	282.9	227.7

G.rubescens 871A 1H 1 124-126 Hole 1

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	16636.5	160.8	132.3	160.9	126.3	142.2	464	1	162.4	137.9
2	17464.1	155.8	143.9	159.3	128.1	145.6	478.4	1	158.8	146.5
3	18502.2	162.7	146.8	161.4	133.7	149.6	534.9	1.2	159.8	151.9
4	19007.1	176.4	138.2	180.1	133.4	152.6	519.8	1.1	182.7	147.2
5	19680.5	171.5	148.1	172.9	133.7	154.8	516.4	1.1	171.1	157.6
6	20087.3	172.3	149.8	173.5	141	156.2	521.5	1.1	172.5	158.9
7	20788.6	171.3	156	170.6	144.7	158.9	521.2	1	171.2	156.7
8	22892.7	178	165.6	181	159.3	167.1	547.6	1	180.6	168.4
9	23594.1	174.3	173.8	180.8	154.8	170.2	558.5	1.1	172.7	167.8
10	24407.7	202	155	199.1	141.8	172.4	573.9	1.1	200.1	163.2
11	26189.2	204.2	165.4	207.8	159	178.4	604.9	1.1	215	175.7
12	26231.3	206.2	163.6	200.2	151.5	179.5	603.4	1.1	198.4	171.3
13	26610	212.8	159.7	210.1	147.3	180.1	603.2	1.1	211.7	161.5
14	27493.7	203.1	174.1	203	161.7	183.6	609.2	1.1	205.9	182.8
15	27605.9	215.5	164.9	213.5	149.2	185	615.2	1.1	208.6	167.8
16	28966.6	215.7	172	207.8	156.5	188.3	624.3	1.1	208.8	170.8
17	29864.4	206.8	186.8	204.5	167.2	191	654.4	1.1	206	202.3
18	30425.5	221.6	175.4	218.2	153.6	192.3	629.9	1	213.7	168.9
19	30748.1	220.4	179.4	215.1	164.3	193.3	645.4	1.1	210.9	184.1

20	31379.3	218.9	183.4	214.5	173.8	197	638.6	1	211	183.9
21	31407.4	206.1	198	236.1	178.4	195.7	775.8	1.5	227.7	212.5
22	31617.8	237.3	173.3	241.7	156.5	194.8	771.9	1.5	232	182.6
23	32066.7	225.6	184	228.5	172.9	198.1	686.5	1.2	233.7	198.2
24	36008.4	232	200	227.4	185	209.1	706.8	1.1	229.5	204.5
25	39795.8	253.1	202.7	255.6	187.3	220.7	746.7	1.1	254.6	209.9

G.rubescens 871A 1H 1 124-126 Hole 2

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	12119.7	132.1	117.8	132.7	108.9	120.4	393.3	1	134.2	121.8
2	14644.6	151.9	123.2	149.1	117.3	134.4	433.7	1	148.8	128.4
3	15121.6	152.6	127.6	152.5	120.4	135.6	452.1	1.1	151.7	131.6
4	15303.9	146.8	133.6	145.9	125.9	135.7	444.4	1	145.4	138
5	16510.3	155.3	136.1	154.4	129.3	142	465.4	1	156.4	135.9
6	17506.2	163.7	137.3	157.9	126.3	145.4	475.9	1	159.3	136.7
7	18432	159	149.4	161.1	135.7	149.4	496.1	1.1	158.9	149.8
8	18488.1	162.6	145.6	159.3	137.4	149.1	486.7	1	158.7	147.5
9	19161.4	174.3	141.9	172.9	134	153.2	524.9	1.1	173.7	142.1
10	20437.9	179.6	146.4	176.7	138.2	157.6	535.5	1.1	178.7	158
11	21391.8	186	147.1	180.1	134.3	162.6	527.4	1	177.6	143.9
12	22514	189.9	151.9	186	141	165.2	547.6	1.1	185.6	155.2
13	23538	205.5	147.9	212.5	126.7	169	602.1	1.2	213.7	148.4
14	23818.5	194.5	157.3	199.9	139.2	170.1	566	1.1	197.6	167.7
15	24337.6	197.1	158.6	190.8	140.2	172.2	572.2	1.1	189.3	159.1
16	26708.2	205.9	166.2	201.9	155.8	180.2	591	1	202.2	171.4
17	27241.2	203.7	175.1	217.2	164.8	182.3	747.3	1.6	223.2	213.1
18	27718.2	194.7	184	196.1	168.9	183.2	619.7	1.1	200.1	189.1
19	34437.3	233.6	190	245.2	169.6	204.1	750.3	1.3	230.6	194.1

20	34844.1	239.1	187.2	234.1	165.9	205.4	688.1	1.1	235.2	187.9
21	35236.9	226.8	200.1	225.8	184.8	207.3	688.4	1.1	225.5	209.6
22	37004.3	223.9	213.7	228.8	192.6	212.7	716.3	1.1	231.4	226.9
23	37663.6	251.4	193.2	244.9	166.9	213.5	721.8	1.1	245.4	197.4
24	40609.4	259.7	203	253.6	168.2	221.7	840.6	1.4	252.9	222.9
25	45266.5	276.4	212.2	270.3	188.3	233.7	806.5	1.1	271.2	215.6

G.rubescens 871A 1H 1 124-126 Hole 3

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	12007.5	126.5	122.3	131.1	112.4	119.8	402.2	1.1	126.2	124.6
2	13185.8	152.7	111.5	153.7	105.9	126.7	466	1.3	154	111.7
3	14041.4	143.8	124.8	144.6	114.2	131	427.5	1	145.2	126.6
4	14139.6	147.2	124.8	157.2	115.7	132	471	1.2	162	121.4
5	14518.4	140.5	132.2	145.9	121.9	132.7	429.4	1	147.5	139.2
6	16089.4	152.2	136.2	156.4	127.3	140.6	464.3	1.1	160.9	133.2
7	16776.8	159.6	134.4	163.2	127.8	144.5	467.3	1	164.4	138.4
8	18614.4	163.2	146.2	162.8	135.7	151.2	495.1	1	159.5	148.3
9	19371.9	173.8	143	169.4	135.7	152.6	511.8	1.1	169	147.8
10	20255.6	169	154.2	183.6	140.8	157	527.5	1.1	184.1	158
11	20774.6	187.8	141.2	182.9	124	158.5	520.3	1	182.3	136.4
12	20928.9	176.6	152.3	174.9	141.8	159.9	527.3	1.1	175.9	150.9
13	21279.6	189	144.2	186.6	134.3	160.3	529.8	1	188.4	151.6
14	21476	175.6	156.8	180.2	145.9	162	540.5	1.1	181.6	169.8
15	22219.4	180.6	158.2	189.9	148.5	165	547.1	1.1	190.8	170
16	22528	195	148.3	191	130	165.6	557.2	1.1	191	151
17	22542.1	171.6	168.1	174.9	157.2	166.1	542.2	1	176	168.7
18	23201.3	184.9	160.9	182.9	147.5	168.4	556.4	1.1	183.3	160.5
19	24758.4	195.5	162.7	192.3	149.8	174.3	572.8	1.1	191.9	169

20	25067	202.7	158.2	206.3	149.8	175.6	577.8	1.1	203.3	165.1
21	25095	183.8	175.8	191.3	164.5	175.9	580.1	1.1	192.8	180.4
22	25459.8	199.9	163.2	195.3	142.4	177.6	586.8	1.1	195.8	160.7
23	26750.3	208.6	165	202.2	133.8	180	609.2	1.1	200.9	166.2
24	26778.3	207.7	166.7	231.2	163.2	180.1	665.4	1.3	232.7	172.8
25	44537	261.1	220.1	263.6	206.4	233.2	782.9	1.1	267.8	229.7

G.rubescens 871A 1H 1 124-126 Hole 4

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	18782.7	164.8	147	172.8	137.4	150.8	521.2	1.2	171.5	155.2
2	19820.7	170.5	149	170.2	137.7	155.4	505.8	1	170.8	144.5
3	19834.8	171.2	149	171	129.1	154.8	583.2	1.4	168.9	167.4
4	20508.1	178.5	148	184.1	139.4	157.8	593.9	1.4	184.3	164.7
5	21055.1	174.7	154.4	174.6	149.2	160.3	526.5	1	175.6	159.8
6	21728.5	182.6	152.6	186	143.4	163	560.6	1.2	188.4	160.5
7	21798.6	171.1	163.8	170.4	156.3	163.5	548.3	1.1	173.5	172
8	22065.1	183.1	154.6	186	143.4	165.2	538.1	1	185.3	157.3
9	22177.3	187	155	206.1	148.2	164.6	628.6	1.4	206.3	159.2
10	23411.8	198.9	154	213.5	135.3	166.9	646.5	1.4	212.4	160.7
11	24127.1	183.9	168.9	192.6	156.8	171.2	571.6	1.1	189.2	175.7
12	24393.7	191.6	164.4	191.6	150.4	172.6	582.6	1.1	197.2	165.5
13	24856.6	190.6	167.7	191.7	157.9	173.8	582.1	1.1	191	174.7
14	25207.3	191.8	169.5	191.9	158.9	175.2	620.2	1.2	197.4	185.3
15	25445.7	206.2	158.1	202.6	133.7	176.7	586.5	1.1	203.3	161
16	25978.8	253.8	151.7	286.5	138.1	172.7	861.8	2.3	296.3	178.4
17	26610	226.9	155.6	264.9	151.5	179.3	789.8	1.9	267.7	167.2
18	26680.1	203.2	169	206.4	155.1	179.9	604.6	1.1	203.4	180.5
19	28826.3	213.3	174.9	235.8	167.4	186.9	724.2	1.4	237.3	188.5

20	29415.5	224.2	171.1	249	163.6	187.8	732.1	1.4	256.1	185.7
21	29555.8	214.2	177	213.5	167.7	189.2	629.7	1.1	213.5	183.9
22	30383.4	238.9	168.6	282.8	156.1	190.4	928.9	2.3	284.2	171.4
23	30706	218.8	179.9	222.1	165.5	193.1	662.4	1.1	221.9	183.3
24	31365.3	225.8	192.2	253.2	165.9	191.6	982.1	2.4	265.5	217.9
25	46528.9	288.8	207.7	307.1	188.2	237.1	874.9	1.3	303.6	231.5

G.siphonifera GLOW 10 BoxBase Hole 1

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	87951.9	389.4	290.3	384.9	237	327.8	1130.5	1.2	387.5	303.2
2	112752	440.1	334.3	444.2	312.3	370.3	1327.6	1.2	449.8	358
3	117227	445.2	337.1	439.1	283.6	379.5	1284.1	1.1	439.4	342.7
4	120566	467.9	332.4	467.8	299.1	383.8	1354	1.2	465.6	365.8
5	120608	466.3	332.4	462.4	270.1	383.4	1340.9	1.2	463.6	348.1
6	120846	454.6	350.9	466.6	320	390.3	1506.9	1.5	467	381.6
7	126822	458.8	356.2	466.6	328.5	394.8	1361.6	1.2	466.8	379.6
8	133218	455.8	377.4	459.9	340.2	407.7	1418.7	1.2	455.4	396.4
9	139292	473.5	379.7	479.6	341.8	414	1445	1.2	479.9	396.7
10	145969	507.1	372	491	292.2	425	1501.4	1.2	487.5	373.8
11	154638	505	392	524.3	354.8	437.3	1585.1	1.3	524.7	429.2
12	155845	539.8	387.6	531.5	317.3	446.9	1562.8	1.2	528.2	389.7
13	158959	521.7	391.5	520.3	356.9	442.8	1521.7	1.2	521.7	400.8
14	161680	521	400.5	512.5	359.9	447.5	1556	1.2	514.9	422.8
15	162662	529.3	398.5	548.8	368.9	447.3	1657.7	1.3	548.5	431.2
16	185905	557.5	435.2	560.6	383	482.8	1791.2	1.4	548.1	449.7
17	201953	597.2	435.5	610.2	405.5	498.1	1769.6	1.2	611	459.4
18	214788	615.5	452.2	605.3	364.5	512.4	1850.1	1.3	604.7	485.6
19	217621	635.3	463.6	648.1	325.8	514	2213.7	1.8	642.8	501.6

20	221437	609.5	471.5	606.8	406.2	523.1	1881	1.3	609	512.6
21	240584	632.1	488.6	627.7	446.7	546.4	1885.6	1.2	627.7	506.8
22	259956	646.7	515.8	640.5	467.3	568	1964.6	1.2	640.4	527.7
23	279594	662.6	548.1	676.8	460.2	588.1	2136.8	1.3	682.7	565.3
24	280885	690.2	523	690.6	452.7	590.3	2041.3	1.2	690	535
25	371151	779.2	621.6	802	572.4	679.8	2492.6	1.3	809.1	670.3

G.siphonifera GLOW 10 BoxBase Hole 2

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	61748.7	339.6	234	338.8	209.6	272.6	971.7	1.2	340.8	252.3
2	65311.6	319.2	261.5	317.9	236.9	284.1	959.4	1.1	325.4	258
3	71469.7	341.6	273.2	354.9	241	294.8	1066	1.3	356.3	295.4
4	76056.6	360.5	271.4	357.1	233.6	304.7	1066.9	1.2	355.4	286
5	83196.6	364.8	294	364.9	273	319.3	1087.2	1.1	363.8	304.8
6	88358.7	399.3	284.1	402.2	263	328.7	1127.5	1.1	402.5	295.9
7	99678.8	418.4	306	415.9	268	349.3	1195.9	1.1	414.7	315.3
8	106538	422.1	325.9	413.6	257.2	362.4	1280.5	1.2	407.2	336.9
9	113117	441.8	329.4	434.9	288.1	372.1	1346.9	1.3	441.3	341.5
10	115502	455.5	326.3	452.9	287.2	375.7	1301	1.2	453.8	345.9
11	115544	486.6	309.8	476.2	234.6	361.8	1547.6	1.6	477.1	326.3
12	127060	469.8	359	479	343.5	401.1	1505	1.4	485.2	381.8
13	127159	458.3	356.9	462	327.6	395.3	1351.8	1.1	460.2	382.3
14	152674	498.4	393.9	494.4	317.5	434.1	1514.3	1.2	491.5	403.8
15	156812	498	404.5	504.7	376.8	440.5	1490.4	1.1	497.7	423.6
16	168455	560	386.7	565.6	367.1	454.7	1613.8	1.2	562.4	412.6
17	171555	539.2	408.5	550.8	347	460.2	1721.8	1.4	532.1	411.7
18	183661	540.2	438.1	560.5	398.8	477	1698.1	1.2	538.3	466.4
19	184264	525.7	452.6	542.4	392.1	478.2	1682.8	1.2	540	488.5

20	202065	586.5	446.1	589.9	404.4	498.4	1748.6	1.2	592	473.5
21	203131	579.8	450.2	576	401.8	500.9	1728.3	1.2	581.1	461.8
22	217888	594	470	600.4	450	520.5	1738.5	1.1	600.2	482.9
23	223835	584.9	497.5	606.8	438.8	525.6	1876.6	1.3	609.8	542.2
24	265890	674.3	512.6	703.3	458.1	571.2	2097	1.3	704.7	560.5
25	280745	686	532.9	702.9	473.3	593.5	2144.8	1.3	699.5	563.3

G.siphonifera GLOW 10 BoxBase Hole 3

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	45434.8	271.4	215.1	266.4	191	235.2	823.3	1.2	265.4	218.5
2	50218.1	292.2	220.4	307.3	210.1	247.7	861.1	1.2	310	230.5
3	56656.7	302.4	240.5	299.6	213.5	263.6	886.9	1.1	301	249.3
4	70684.1	347.5	262.9	350.7	243.9	293.4	1014.5	1.2	348.9	284.3
5	72185.1	346.8	266.9	344.5	238.2	297.7	1000.9	1.1	347.1	280.5
6	75621.8	349.6	277.4	348.3	248.2	304.6	1021.7	1.1	348.6	290.2
7	83028.2	392.2	275.9	396.7	248.6	316.2	1150.8	1.3	396.3	307.4
8	86773.6	384.8	288.5	391	275.5	327	1094.7	1.1	390.8	298.9
9	86927.9	390	289.9	380.7	210.9	323.7	1186.1	1.3	380.1	307.2
10	95091.8	401.8	303.4	398.8	266.9	341.5	1159.9	1.1	400.8	312.6
11	97574.7	409.6	309.4	434.8	293.1	347	1337.1	1.5	435.7	321
12	102849	433.2	310.7	423.8	253.5	353.1	1277.7	1.3	424.7	325.2
13	106552	428.7	321.4	432.7	259.3	360.5	1286.1	1.2	425.2	340.7
14	106861	435	317.6	430.7	277.2	360.8	1283.8	1.2	431.4	331.8
15	108137	405.1	347	407.4	263.3	363.9	1307.4	1.3	401.1	355.7
16	112219	445.6	323.3	438.2	278.4	370.9	1261.7	1.1	439.1	335.4
17	117339	462.7	327.6	459.9	300.8	377.8	1326	1.2	461.5	354.7
18	134060	486.9	356.5	487.9	320	403.9	1433.5	1.2	489.6	385.1
19	167740	518	421.2	551	383.6	454.3	1655.4	1.3	554.3	447.8

20	178443	528.9	432.9	527.3	395	470.8	1598.3	1.1	523	454
21	178625	551.4	417.4	541.1	357.1	469.4	1635.8	1.2	532.9	445.7
22	194294	535.7	467.3	557.5	436.2	492.1	1712.9	1.2	562.2	490.5
23	264697	662.2	521.6	678.3	370.8	570.7	2168.4	1.4	680	537.7
24	319194	748.3	550.2	752.1	498.9	629.6	2185.5	1.2	752.1	574.6
25	456943	869.3	678.1	877.3	647.2	754.2	2658.5	1.2	877.5	714.8

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	73868.3	369.7	257.3	365.2	228.5	298.7	1033.9	1.2	363.7	273.3
2	87068.1	387.3	288.4	388.8	271	326.5	1114.8	1.1	388.5	296.9
3	103747	436.5	308.6	417.3	237.3	354.4	1328.5	1.4	416.9	323
4	104799	423.7	317.9	424.3	278.9	358.7	1238.2	1.2	424.5	332
5	105949	440.5	313.7	425	221.8	353.8	1383.9	1.4	420.7	331
6	106370	432.8	320.9	435.8	297.4	364.4	1358.8	1.4	435.4	342.1
7	107282	411.6	334.2	414.7	311.8	364.3	1235	1.1	417.2	351.9
8	120916	447	349.6	449.4	319.4	385.2	1338.2	1.2	450.4	377.7
9	124423	480.8	331.8	472.8	297.4	390.2	1374.8	1.2	471	335.5
10	129824	482.4	348.4	486	315.3	397.7	1441.3	1.3	483.6	374.2
11	133036	461.7	371.7	456.2	327.2	404.8	1389.2	1.2	456.1	396.4
12	147498	501.6	378.5	502.7	330.9	425.8	1505.7	1.2	504.1	403.9
13	149616	474.4	406	493.6	374.6	430.4	1482.4	1.2	485.9	430.4
14	150963	505.2	385	501.7	312.3	432.4	1534.1	1.2	502.1	397.1
15	151061	508.2	380.5	500.9	316.2	431.6	1480.4	1.2	498.2	376.5
16	155831	519.3	389.2	501.3	289.6	438	1568.4	1.3	491.7	390.7
17	170377	542.3	402.5	536.1	354	458.5	1562.4	1.1	535.6	408.2
18	180813	546.6	426.3	546.8	385.8	472	1618.6	1.2	547.4	453.2
19	187939	566.8	431.2	574.5	385.6	484.8	1691.8	1.2	571.8	454

20	223330	633.6	455.6	644.5	415.7	523.6	1876	1.3	645.7	483.1
21	246083	652.9	497.5	670.4	407.2	548.6	2214.1	1.6	674.7	540.3
22	261022	657	508.7	652.6	466.7	569.1	1956.1	1.2	652.4	505.9
23	283999	717.7	518.3	715.9	313.7	578.1	2439	1.7	711.5	579.8
24	287562	697.8	531.7	691.2	465.2	599	2077.2	1.2	691.9	540.1
25	346547	757.1	595.3	783.7	533.5	654.4	2416.2	1.3	785.7	655.1

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	47791.4	277.4	220.3	270.9	198.5	241.9	790.3	1	272	214.8
2	51284.2	289.6	226.5	279.9	191.6	250.4	827	1.1	277.5	217.9
3	52111.8	299	224.4	288.7	199.1	251.7	861.8	1.1	281.3	230.4
4	53332.2	297.5	229.9	288.1	198.3	255.2	852.6	1.1	286.3	221.9
5	57582.5	304.8	241.2	297.8	221.1	266.1	871.8	1.1	299.3	240.8
6	58480.3	303.5	246.8	300.2	218.4	267.7	925.6	1.2	298.5	236.6
7	61860.9	309.7	255.1	302	232.1	276.3	899.6	1	300.5	246.9
8	62856.8	314.3	256.7	310.1	224.7	277.5	925.2	1.1	302.8	254.4
9	63305.7	319.4	253.8	308.6	223	278.5	924.4	1.1	317.5	247.6
10	67696.3	334.6	259.3	321	217.3	288.1	964.4	1.1	319.5	253.9
11	69000.8	324.2	273.4	320.1	240.8	291.2	961.8	1.1	317.4	270.5
12	76968.4	353.6	279.1	345.2	243.5	307.8	1017.5	1.1	337.5	274
13	77094.6	356.8	276.8	343.7	239.7	307.9	1018.9	1.1	344.1	267.1
14	79689.7	359	290.1	358.6	256.4	318.7	1045.9	1.1	354.1	294.7
15	81443.1	361.8	288.2	353	251.1	316.8	1046.1	1.1	350.6	277
16	82789.8	366.4	289.3	359	254.9	318.6	1063.7	1.1	355.9	284.8
17	83926	365.4	294.3	358.3	259.4	321.7	1060.1	1.1	355.6	283.2
18	85707.5	384.8	286.7	370.4	233	324.1	1095.6	1.1	362.5	274.4
19	88274.5	385.5	295	371.9	240.4	328.8	1130.2	1.2	368.2	289

20	90518.9	397.4	294.3	382.6	236	333.7	1135.6	1.1	379	284.9
21	93885.5	389	309	386.4	277.2	340.5	1127.8	1.1	389.2	305.7
22	104813	408.4	327.9	400	289.6	360.1	1189.7	1.1	399	319.4
23	113243	421.1	345.1	422.5	312.3	374.1	1255.1	1.1	417.4	348
24	115418	425.9	346.8	419.4	292.1	377.8	1267	1.1	420.1	348.7
25	119303	460.2	331.8	448.9	288.4	382.3	1295.6	1.1	449.6	341.1

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	55268	298	238.7	293	213.5	259.5	874.5	1.1	288.4	234.3
2	55997.4	301.3	239.1	297.4	210.1	263.4	873.2	1.1	290.2	236.2
3	56165.8	303.9	238.7	298.2	198.8	261.5	887.3	1.1	290.5	236.1
4	56881.1	297.6	244.5	293.8	214.5	264.5	874	1.1	286.8	238
5	57428.2	295	248.2	297	233.3	266.1	867.3	1	297	248.1
6	57877.1	299.7	247.3	298.5	216.7	266.9	879.2	1.1	287.9	239.6
7	58578.5	318.8	236.1	306.7	194.6	266.8	904.7	1.1	301.9	235.7
8	59027.3	308.5	245.6	301.2	206.4	268.6	891.9	1.1	299.4	242.2
9	60640.5	324.5	239.7	316	205.2	271.6	918.7	1.1	312.4	234.9
10	61440.1	312.3	252.3	307.4	217.3	274.3	909.5	1.1	301.1	247.2
11	64512.1	328.7	250.8	323.1	238.1	281.3	929.1	1.1	322.2	254.7
12	65087.2	324.7	257.2	317.8	221.8	284.1	935.2	1.1	314	249.1
13	65900.8	331.8	255.2	318.7	214.7	284.1	956.6	1.1	316.1	248.8
14	65914.8	308.9	273.2	308.8	253.3	284.8	939.8	1.1	308.3	275.6
15	67556	335.8	258.2	335.5	224.8	287.7	976.1	1.1	319	258.6
16	71778.3	353.4	261.3	349	217.4	295.9	1001.9	1.1	344.6	265.8
17	78343.1	359	280.2	345.9	237	309.6	1052.3	1.1	340.3	291.7
18	81765.8	356.3	294.5	349.8	274.7	319	1041.7	1.1	344.4	291.8
19	86030.1	372.1	295.9	364.6	251.9	325.3	1075.2	1.1	358.5	288.7

20	88513	368.9	306.4	362.9	273.4	331.2	1077.2	1	364.2	305.8
21	89677.2	385.4	297.7	384	273.4	332.5	1121.1	1.1	386.2	301
22	101923	416	313.8	415.8	284.6	355.2	1187.2	1.1	403.5	312.6
23	103719	421.4	315.5	417.2	277.2	356.9	1192.5	1.1	412.1	318.3
24	108165	407.6	341.6	408.2	289.1	365.4	1232.3	1.1	393.4	340.5
25	131128	452.7	371.2	455.4	339.4	403.1	1378.3	1.2	458.1	391

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	44957.9	269.6	213.5	266.2	187.3	234.8	798.2	1.1	267.1	224.5
2	49797.3	281.6	226.7	281.8	203.1	246.3	817.7	1.1	267.3	223.7
3	50456.6	279.5	231.2	273	205	248.6	819.7	1.1	267.9	225
4	55506.5	301.2	238	297.4	184.9	260.5	892.5	1.1	286.1	235.2
5	60500.2	299.6	258	296.1	230.8	273.3	904.2	1.1	294.3	260.8
6	62001.2	316.6	250.5	308.6	228.5	276.5	906.8	1.1	311.3	245.1
7	64007.1	323.3	253.3	317.2	222.6	280.8	924	1.1	317.8	249.4
8	66504	324.7	262.2	321.7	225.5	286.2	945.9	1.1	310.9	249.8
9	66966.9	337.1	254.8	337.4	221.8	286.1	952.7	1.1	333.9	262.3
10	69393.6	333.2	266.7	329.9	237.4	292.1	970.7	1.1	330.5	261.2
11	69632.1	344.9	258.6	336.5	221.8	292.1	974.8	1.1	330.2	251.9
12	71441.6	337.9	270.5	335.2	247.2	296.7	984.1	1.1	324.2	271.2
13	72451.6	341.7	271.7	344.4	229.2	298.1	1006	1.1	329.7	270.5
14	73728.1	343.1	274.6	341.6	247.9	301.8	987.6	1.1	340.3	267.1
15	76729.9	351.5	279.2	343.5	243.4	307	1026.6	1.1	344.5	272.8
16	78385.2	356.7	281.3	346.4	240.8	310.3	1056.1	1.1	340	271.7
17	80433.2	359.5	287	348.5	240.8	314.6	1045.4	1.1	340.4	276
18	84655.4	375.2	289.4	362.4	247.6	323	1065.3	1.1	357	279.2
19	88442.8	378.4	299.9	367.9	259.4	330.1	1096.5	1.1	363.1	295

20	91542.9	382.4	306.1	378.3	273.4	336.3	1112.8	1.1	375.6	302.2
21	95442.5	399.5	305.7	391.3	265.3	343.1	1137.5	1.1	384.6	302.8
22	96424.4	396.8	311.7	390.6	273.4	344.1	1143.3	1.1	386.4	299.9
23	101573	408.3	317.9	410	286.4	354	1169.4	1.1	401.4	319.7
24	110592	431.6	329.7	416.6	274.7	368	1289.1	1.2	419.1	325
25	116484	450.9	333.4	445.3	280.9	377.1	1315.4	1.2	442	339.3

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	46528.9	264.9	224.5	258.7	202.2	239.1	776	1	251.6	214.7
2	47524.9	275.4	220.6	267	191.9	240.9	787.5	1	264.7	211
3	50989.6	283.7	231.7	278.4	202.2	249.5	846.1	1.1	277.8	232.2
4	56488.4	309	234.6	300.7	205.3	262.7	877.8	1.1	295.9	230.1
5	56670.7	309	234.2	304.5	203.5	263.3	873	1.1	303.5	228.7
6	61622.4	312.1	253.2	305.4	218	274.6	905.3	1.1	299.4	242.4
7	62604.3	312.7	256.1	311.2	225.8	277.7	909.5	1.1	301.9	250.5
8	63389.9	324.3	250.5	311.2	218.1	278.7	928.3	1.1	309.5	245
9	66111.2	323.7	261.6	324.7	232.2	285.1	946.2	1.1	324	261.5
10	66209.4	340.6	250.8	333.2	213.5	283.2	967.1	1.1	330.3	248.4
11	66784.5	332.6	256.2	328	224.7	286.8	940.5	1.1	330.1	248.7
12	67738.4	332.6	260.8	337.1	227.1	287.9	972.4	1.1	329.7	253.6
13	68467.8	342.8	257.7	337.2	228.6	292.3	963.7	1.1	336.5	252.9
14	69281.4	344	259.4	330.5	225.5	290.8	982.9	1.1	332.6	258.7
15	70824.4	327.5	276.9	325.2	246.9	295.4	975.4	1.1	322	272.9
16	70866.5	334.5	271.2	326.3	241.8	295.6	978.1	1.1	326.7	263.2
17	71581.9	351	261.2	347.8	228.5	295.7	989	1.1	346.7	268.4
18	76253	344.2	283.2	335.1	259.1	307	999.1	1	326.7	275.5
19	83701.6	363	294.4	362.7	277.3	321.4	1060.4	1.1	357.6	298.5

20	86450.9	373.9	296.9	368.6	249.8	326.3	1093.9	1.1	363.5	290.9
21	95751.1	404.8	311.7	399.5	285.8	352.7	1161.1	1.1	397.8	314.9
22	96634.8	399	310.3	393	274.7	344.6	1146.4	1.1	387.9	302
23	106216	420.8	322.8	410.7	294.1	362.4	1191.6	1.1	401.6	319.1
24	108502	424.9	330.8	421.5	285.8	364.6	1277	1.2	415.4	351.8
25	130511	461.6	365.1	458.5	322.1	400.9	1435.2	1.3	451.9	371.6

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
3	186242	574.5	424.3	577.2	392.1	476.4	1675	1.2	579.4	472.7
4	209163	620	435.8	624.7	399.1	505.6	1764.2	1.2	627.5	468.2
5	210902	628.7	435.3	653.1	440.4	507.8	1811.8	1.2	656.6	471.5
6	212992	604.4	461.9	614.2	438.4	513.5	1794.9	1.2	617	494.6
7	214900	645.8	428	626.5	329.6	511.9	1781.4	1.2	626.2	430.6
8	221044	631.3	456.9	613.4	331.3	521.1	1871.1	1.3	607.8	468.4
9	221675	614.7	466.6	601.5	364.9	521.7	1833.8	1.2	592.4	467.8
10	223022	633.5	464.2	618.2	421.9	523.3	1901.3	1.3	624	509.4
11	232869	645.4	471.6	644.4	418.2	532.8	1895.8	1.2	648	496.5
12	237218	648.1	477.1	626.2	380.1	542.5	1897.8	1.2	621.7	479.3
13	238522	636.7	487.7	662.2	477.4	541.9	1888.3	1.2	655.7	516
14	239350	664.3	465.9	696	445.6	541.5	1898.2	1.2	692.1	494.2
15	253854	682.3	479.4	689.1	384.6	557.9	1964.1	1.2	682	499.2
16	266114	700.2	499.4	703.9	453.8	574	2041.3	1.2	699.3	541.5
17	275442	736.2	487.6	746.6	449.5	579.1	2066.7	1.2	744.9	521.5
18	282708	744.2	497.1	763.9	476.8	594.3	2130.2	1.3	765.8	537.9
19	338061	781.5	566.4	757.7	414.4	647.6	2386.2	1.3	753.5	589.9
20	358961	812.6	576.9	824.4	560.5	666.5	2316.5	1.2	840	615.7
21	369426	819.6	587.6	865.7	477.7	672.6	2468.7	1.3	859.6	629.5

22	406290	853.4	620.7	867.5	583.8	705.9	2516.9	1.2	872.6	664
23	420892	892.2	619.8	878.4	527	722.6	2605.7	1.3	876.1	648.8
24	478377	981.5	645.6	938.5	492.9	757.4	2831.9	1.3	932.5	715.3
25	491633	970	666.8	979.7	580.5	783	2780	1.3	991.1	699.7
26	543913	1012.2	702.2	1003.4	631.7	822.7	2923.9	1.3	1008.4	733.1
27	559427	929.9	783.1	944.3	649.9	836.1	3038.3	1.3	910.3	800.1

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	117227	459.4	328.6	445.2	277.1	378.4	1310.8	1.2	443.4	321.7
2	136304	485.6	362.5	489.3	307.4	408.7	1402.1	1.1	480.8	364.6
3	145212	504.9	370.2	488.6	279.1	421.7	1457.9	1.2	486.2	368.1
4	147863	506.2	379.9	492.7	315.9	427.1	1485.4	1.2	489.3	393.2
5	171990	551	405.9	534.7	343	459.2	1675.2	1.3	528	413.2
6	176521	552.6	412.8	541.1	381.2	465.5	1584.5	1.1	540.1	426.7
7	178316	567.3	409.3	553.1	333.4	466.5	1656	1.2	551.7	431.4
8	179958	570.1	415.4	556.8	379.8	471.8	1655.4	1.2	557.2	435.7
9	191236	572.4	438.6	568	401.3	484.5	1692.1	1.2	567.6	468.4
10	215994	627.4	444.6	640.7	439.2	514.4	1780.6	1.2	641	471.4
11	220160	638.6	444.4	617.1	316.8	517.7	1858.7	1.2	616.9	441.8
12	236544	665.7	459.1	685.9	401.8	540.7	1939.3	1.3	683.3	491.6
13	258890	689.5	487.1	672.1	415.7	562.7	1987.1	1.2	666.9	509.5
14	282484	729.3	501.1	705.9	417.8	586.2	2116.5	1.3	697.8	524.5
15	292317	722.8	529.5	735.8	499.7	597.9	2140.6	1.2	739.3	554.6
16	294393	740.6	519	731	477.1	598.4	2137	1.2	736.6	559.3
17	307453	744	533.2	760.9	438.3	614.8	2171.8	1.2	755.3	546.6
18	359438	823.8	562.1	860.1	537.8	664.6	2364.5	1.2	860.4	602.4
19	363268	845.1	559.1	836	504.2	668.2	2375.5	1.2	834.2	594.9

20	397831	912.3	580	864.6	216.7	639.3	2987.7	1.8	856.4	617.2
21	421818	861.7	640.5	895.2	595.1	722.8	2572.8	1.2	890.6	676.1
22	427892	898.2	633.3	886.2	516.9	733.4	2594.5	1.3	882	644
23	428916	903.8	622.4	901.5	554.6	725.4	2669.1	1.3	900.1	658.2
24	471054	869.9	716.1	917.7	520.9	763	2846	1.4	871.6	779.4
25	559792	1057.8	697.1	1079.3	676.5	830.1	3045.1	1.3	1079.7	785.4

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	104490	438.3	307.3	425.5	272.7	356.3	1228.3	1.1	425.2	311.7
2	128070	472.6	355.2	470.1	334.4	398.1	1382.9	1.2	470.6	376.6
3	130118	484.4	346.3	514.5	281	398.7	1490.2	1.4	511.2	341.1
4	136964	492.2	361.5	475	331.1	410	1416.9	1.2	474.5	378
5	144328	523.6	354.5	502.2	312	418.6	1436.8	1.1	501.6	357.7
6	151538	522.5	372.1	509	316.4	430.9	1476.8	1.1	508	364.7
7	154596	538	368.8	523.6	292.7	434.7	1491.5	1.1	523.3	368.8
8	155831	529.2	379.1	514.1	289.4	436.3	1512.6	1.2	511.8	375
9	158313	553.6	368.6	535.6	304.8	438.7	1534.4	1.2	536.4	382.4
10	158874	533.4	383.9	533.5	368.6	442.9	1499.3	1.1	533.9	400.7
11	159618	546.2	374.8	531.1	296.7	441.3	1510.1	1.1	531.1	370.8
12	164850	573.5	373.7	556.1	320	446.5	1612.7	1.3	556.8	391
13	167964	559.1	388.6	541.4	357.8	452.3	1579.6	1.2	541.4	406.6
14	171134	534	410	530	366.5	460.2	1539.9	1.1	534.1	411.9
15	189244	608.2	401.2	584.7	312	479.1	1683	1.2	586.8	415
16	211253	623.9	438.6	604.1	331.3	506.7	1798.7	1.2	601.2	450.8
17	225126	665.8	445.6	640.5	370.2	528.4	1846.5	1.2	642.3	463.7
18	245325	660.3	482.1	639.7	361.5	547.3	1977.5	1.3	638.3	497.8
19	264908	713.7	482	683.8	353.7	568.1	2009.6	1.2	677.9	491.2

20	284448	748	504.9	774.6	484.1	590.3	2146.5	1.3	777.6	549.2
21	286833	718.5	525.3	701.8	391.3	591.1	2162.4	1.3	688.8	561.6
22	294968	677.5	571.7	721.3	526.1	604.7	2198.3	1.3	738.3	618.2
23	306246	779.5	520.8	794	491.3	620.6	2197.9	1.3	792.7	545.6
24	336490	804	546.4	767.7	456.9	641.7	2271	1.2	764.4	562.1
25	669837	1152.2	776.7	1140	616.5	908	3439	1.4	1139.9	814.8

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	104532	431.9	312.5	443.7	278.4	358.1	1278.4	1.2	450.6	326.4
2	113510	437.1	332.7	453.2	321.6	374.4	1253	1.1	453.7	342.7
3	114113	462.2	320.1	456.9	315.1	372.5	1288.5	1.2	461.4	339.3
4	123666	462.9	352.3	452.8	309.9	387.8	1400	1.3	455.1	376.6
5	126864	472	344.5	459.9	300.8	394.7	1334.8	1.1	458.7	336.4
6	129782	479.9	347.2	472.8	281	399.2	1394.3	1.2	472.8	364.4
7	130146	495.7	337.7	479.9	260.2	397.8	1374.5	1.2	478.7	334.5
8	133850	491.6	348.7	485.6	295.3	404.9	1369.9	1.1	487	343.3
9	137833	516.4	346.6	520.3	252.9	406.9	1553.1	1.4	515.5	362
10	143767	521.3	354.6	510.5	286.6	418.2	1442.5	1.2	510.5	358.1
11	145057	505.8	367.9	498.1	302.1	422.1	1448.7	1.2	497.3	369.8
12	146544	526	361.8	517.2	335.4	424	1457.4	1.2	515.9	372.4
13	147428	471.7	403.8	498.1	402.9	429.3	1437.7	1.1	504.1	413.5
14	149981	537.7	359.2	520	277.2	426.1	1496.3	1.2	517.8	357.2
15	164570	556.7	378.4	542.2	312.3	448.5	1525.7	1.1	543.3	368.4
16	190997	591.4	415.8	572.4	326	483.4	1670.8	1.2	573.1	418.1
17	198432	588.7	434.2	573.2	345.6	494.2	1695.3	1.2	571.3	429.4
18	233809	633.1	483	654.8	446.6	536.5	1899.1	1.2	652.9	493.5
19	260699	713.1	479.7	682.7	410	565.6	2031	1.3	686.3	504.6

20	267306	726.4	485.6	724.4	445.9	574.1	2078	1.3	729.6	520
21	270813	717.8	489.3	700.4	368.9	574.7	2062.6	1.3	700.7	508.3
22	273661	710.2	500.9	691.2	395.4	576.9	2050.4	1.2	691.2	529.6
23	316500	758.4	539.4	740.4	409.1	622.3	2313.7	1.3	743.3	560.4
24	329897	737.7	586	725.5	491.8	639.2	2347.6	1.3	715.9	604
25	341077	799.1	554.2	791.8	396.7	644.9	2342.5	1.3	790.4	578.9

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	102021	434.4	306.2	442.6	275.4	351.1	1259.6	1.2	434.2	327.4
2	104224	438.3	312.1	427	282.1	355.6	1279.6	1.3	428.1	337.9
3	110522	445.2	322.8	436.8	297.7	366.3	1284.1	1.2	437.7	344.3
4	123596	476.1	336.2	456.9	243.2	386.7	1379.7	1.2	458	337.2
5	126022	465.7	350.9	458.5	324.7	394	1348.5	1.1	458.8	369.6
6	129431	451.8	372.9	464.4	355.5	400.9	1377.6	1.2	469.1	386.8
7	142056	517.5	352.8	504.6	301.1	415.9	1436.7	1.2	503	353.1
8	143781	521.2	354.9	508.3	293	418.2	1456.9	1.2	509.3	353.4
9	143823	514.3	367.7	534.5	310	417.2	1537.5	1.3	537.9	398.4
10	154484	511.6	390.7	501.7	295.9	434.9	1524.5	1.2	495.7	400.9
11	156672	550.9	365.1	535.7	292.1	436.3	1512	1.2	534.5	367.3
12	163083	543.6	387.1	527	274.7	445.8	1590.4	1.2	529.1	396.7
13	164331	505.8	431.9	511.1	332	453.7	1921.6	1.8	510.4	500.2
14	166856	509	431.2	519.5	408.7	455	1638.7	1.3	523.5	451.3
15	168343	568.4	385.1	560.9	342.4	450.2	1628.3	1.3	560	404.7
16	169269	497.4	443.4	511.1	414	457.3	1595.3	1.2	527.7	447
17	176872	565.7	404.4	550.9	317.5	464.3	1638.1	1.2	551.8	421.3
18	197001	591.6	440	584.3	391.6	492.6	1764.8	1.3	591.5	460.7
19	213974	591.8	466.7	582.6	395.7	516.1	1767.5	1.2	580	458.3

20	214760	633.1	444.8	618.5	372	509.8	1856.2	1.3	615.4	480.1
21	225364	652.9	455.4	657.5	406.2	526.5	1903.4	1.3	649.3	475.5
22	244063	648.3	499.1	650.1	457.6	550.4	1980.1	1.3	650.4	526.1
23	271402	684.6	512.6	678.6	425.6	577.6	2040.4	1.2	679.4	535.1
24	271599	687.1	523.7	683.9	463.5	577.3	2214.2	1.4	669.6	539.2
25	281530	723.8	517.2	749.1	405.9	586.8	2204.5	1.4	742.7	540.1

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	65255.5	366.1	232.7	346.2	166.9	275.4	1072.4	1.4	349	241
2	70291.4	373	244.5	357.7	168.9	292.6	1041.3	1.2	358.1	246.1
3	87503	390	289	374.6	233	326.8	1111	1.1	373.3	289.6
4	91262.3	410.3	285.3	401	228.5	333.8	1147	1.1	400.7	282.3
5	99973.4	394.8	329.1	399.3	318.6	351.1	1191.2	1.1	398.2	338
6	106987	445.3	310.7	426.5	232.1	360	1269.7	1.2	416.6	307.7
7	107113	444.9	320.7	442	259.3	361.1	1348.1	1.4	442.8	350.2
8	127734	478.8	348.7	471.5	316.4	394.6	1395.1	1.2	470.9	375.5
9	136150	498.9	351.6	480	281.4	407.1	1417.3	1.2	477.6	341.6
10	138030	497.8	364.7	480.9	321.1	408.9	1505.9	1.3	480.8	411.3
11	146039	499	383.9	494.4	359.6	425	1527.4	1.3	499.8	412.2
12	156041	552.2	363.5	535.6	279.1	433.5	1567.6	1.3	536.5	363.2
13	163335	547.3	386.8	536.1	334.4	448.1	1546.4	1.2	536.8	401.1
14	166786	572.5	378.1	588	283.9	448	1671.2	1.3	585	407.6
15	167277	557.2	387.5	535.6	301.9	451.1	1583.2	1.2	535.2	392.3
16	168413	530.7	416.4	524.3	391.3	459	1566.6	1.2	535	439.6
17	186494	573.6	422.7	570.5	388.1	477.8	1678.6	1.2	570.6	451.5
18	188949	586.7	415.4	578.1	366.3	482	1681.3	1.2	577.1	431.1
19	209654	627.8	439	616.8	361.1	505.9	1866.3	1.3	613.6	463.3

20	223274	637.7	459	618.5	394.6	522.1	1882.7	1.3	615.6	482.4
21	234665	654	471.5	626.6	360.8	537.4	1918.8	1.2	625	483.2
22	234749	645.6	471.6	634.8	353	535.8	1936.4	1.3	621.1	480.3
23	241875	674.7	467	673.4	360.8	541.3	1998.8	1.3	671.5	505.4
24	250614	678.8	489	685.4	436.8	558.5	2077.6	1.4	688.9	517.8
25	266114	701.6	514.7	683.8	455.5	581.1	2146.4	1.4	682.3	548.7

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	76898.3	367.6	268.6	360.3	226.7	306.5	1047.6	1.1	360	265.6
2	86563.1	352	319.7	361.5	305.4	329.1	1118.6	1.2	369.6	327.1
3	87446.9	368.4	308.2	366.7	269.1	327.1	1156.8	1.2	363.2	311.2
4	93885.5	399.8	301.6	385	255.6	339.6	1141.8	1.1	385.2	296.9
5	103578	460.9	291.6	437.1	186.4	349.9	1298	1.3	437.2	290.8
6	104771	417.2	323.6	412.2	298.2	359.1	1262.2	1.2	415.2	331.5
7	110087	450.4	315.8	438.2	282.1	369	1254.9	1.1	438.6	314.8
8	111897	442.1	323.9	437.2	277.2	370.8	1245.7	1.1	436.6	324
9	114590	444.9	335.9	438.5	309	375	1301.5	1.2	438.7	354.2
10	120145	485.3	324.3	466.2	293.8	383.5	1360.3	1.2	468.4	341
11	122305	477.2	330.3	459.1	256	385.6	1337.5	1.2	457.1	326.4
12	127215	490	333.1	475.3	285.8	393.6	1352.9	1.1	477.4	331.6
13	135182	505.9	342.4	491.8	274.3	406.1	1389.2	1.1	491.5	333.1
14	142028	491.1	373	479.2	320.3	417.6	1445.5	1.2	474.8	376.9
15	142561	505.8	365.2	509.4	271.3	416.4	1477.5	1.2	495.5	374.7
16	142995	505.2	364.2	488.2	309.2	418.8	1438.5	1.2	491.7	369.3
17	148508	517.5	371.9	497.7	322.1	425.2	1544.1	1.3	488.9	386.9
18	154119	544.9	368.2	539.1	277.2	433	1652.2	1.4	518.2	365
19	155073	552.1	363.3	531.8	284.7	432.4	1536.4	1.2	533.4	369.9

20	184937	562.6	429.9	552.1	378.3	475	1710.8	1.3	551.7	461.6
21	187182	614.7	399.2	602.2	304.6	476.8	1754.9	1.3	597.5	414.5
22	201602	618.7	427.1	603	357.1	493.1	1798.9	1.3	608.3	466.7
23	209682	631.4	432.6	616	359.2	505.1	1801.4	1.2	615.3	454.9
24	216247	625.6	450.8	608.8	373.9	515.1	1871.6	1.3	611.2	483
25	241664	672.5	475.7	675.3	421.5	545.4	1949.4	1.3	678.7	510.4

G.trilobus.sacculifer 872C 2H 6 122-124 Hole 4

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	57007.4	316.4	231.6	301.5	193.1	263.3	897.2	1.1	302.5	223
2	67850.6	352.5	248.7	341	191.9	285.6	1021.9	1.2	342.6	246.4
3	74513.6	357.1	268	347.4	218	301.4	1028.7	1.1	344.4	259
4	83743.6	395.3	273.9	380.3	225.8	319.1	1111.8	1.2	374.9	279.6
5	83912	380.3	283.6	366.5	237	320.4	1091.9	1.1	362	277.4
6	85426.9	411.4	270.8	394.6	194.3	319.4	1150.9	1.2	393.2	277.5
7	87769.5	369.8	307	368.4	294.1	329.1	1118.6	1.1	370.2	318.3
8	90098.1	372.8	313.7	385.8	290.1	335.3	1157.3	1.2	390.8	321.5
9	90617.1	403	291.4	390	270.5	331.7	1148.8	1.2	387.6	301.3
10	98809.1	412.9	306.5	403.8	258.6	348.1	1165	1.1	400.7	297.8
11	106131	437	312.1	426.5	250.9	360.1	1229.9	1.1	420.6	309.8
12	106454	426.4	332.3	466.2	281.5	374.1	1343	1.3	460.9	345.7
13	116021	465.5	321.3	457.4	275.5	376.1	1310.5	1.2	457.7	326.2
14	116933	446.2	338.9	452.5	270.6	378.1	1321.6	1.2	432.6	339.5
15	122193	485.6	329.3	486.9	244	384.4	1415.8	1.3	494	348.2
16	123553	484.4	327.9	468.2	251.6	387.4	1357.5	1.2	468.3	325.5
17	125447	483.5	333.8	470.3	265.9	390.4	1354.6	1.2	467.3	331.6
18	125616	483.5	336.4	476.7	309.2	390.2	1370.6	1.2	476.9	356.9
19	128912	503	328.8	486.8	258.5	395	1371.7	1.2	487.5	324.9

20	129585	479.2	347	467.4	278.4	398.3	1360.9	1.1	468.2	340.7
21	130413	441.8	379.7	453.4	336.9	402	1353	1.1	439.8	380.4
22	157738	544.4	372	533.4	288.4	438.8	1549.1	1.2	532.3	375.7
23	167796	569.7	384.3	558.1	359.1	451.1	1605.2	1.2	564.9	417.9
24	168778	535.6	413.1	538.9	393.7	457.9	1578.5	1.2	544.6	432
25	211253	602.5	458.7	589.9	406.4	508.4	1808.9	1.2	587.3	490.3

G.bisphericus.P.sicanus 871A 1H 1 124-126 Hole 1

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	47805.4	282	217.5	273.2	187.3	240.8	805.8	1.1	273.4	210.8
2	49194.1	280.9	223.6	277.3	199.1	246	804.5	1	276.3	224.3
3	52196	291.9	228.9	290	199.9	252.9	844.1	1.1	289.3	226.6
4	57273.9	299.2	244.9	297.4	206.5	265.2	888.6	1.1	296.7	242
5	58620.5	306.3	244.4	303.9	229.6	268.8	878.1	1	303.5	245.8
6	63628.3	319.6	254.9	315.3	236.7	279.8	937.1	1.1	311.1	255.6
7	73475.6	351.7	267.4	340.8	237.2	299.9	999.7	1.1	339.4	254.6
8	74191	347.1	274.4	348.9	236	302	1030.6	1.1	341.8	278
9	74780.1	349.1	274.7	341.7	233.6	303	1017	1.1	340.1	272.8
10	77852.1	365.7	273.5	357.1	237	308.7	1055.7	1.1	352	269.9
11	78357.1	357.6	280.9	350.7	245.4	310.4	1041.9	1.1	349.1	279.2
12	80447.2	368.8	280.2	361.7	244.9	314.1	1075.4	1.1	352.5	273.5
13	80517.3	364.1	283.1	359.2	263.7	314.7	1050	1.1	359.1	285.5
14	82761.7	363.1	291	370.9	277.2	319.8	1074	1.1	370.3	295.7
15	83266.7	376.1	283.7	369.8	248	320.3	1125.6	1.2	367.1	279.7
16	84192.5	372.5	289	366.5	260.8	321.9	1087	1.1	367.1	288.4
17	86521.1	382.1	291.1	377.2	278.8	326.2	1105.1	1.1	375.9	308
18	88737.4	388.4	293.3	378.7	250.9	330	1140.5	1.2	375.7	286.8
19	96550.7	407.5	303.5	397.3	259.3	344.3	1165.1	1.1	397.5	307.9

20	107604	403.9	341.1	407	321	365.2	1220.1	1.1	401.5	349.7
21	113159	446	324.7	440.5	286.5	372.9	1251.9	1.1	436.7	327.3
22	122964	475.4	331.4	472.6	289.9	388.2	1347.2	1.2	467.3	334.8
23	125433	475.4	338.5	467.3	288.4	391.5	1341.8	1.1	467.7	339.7
24	134635	484.8	355.4	476.1	310.9	407.4	1376.7	1.1	476	357.7
25	145422	495.3	375.8	489.8	351.1	423.9	1430.3	1.1	490.4	384.8

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	42068.2	254.5	211.1	251.9	191	227.3	741.2	1	251.2	212.4
2	55787	295.5	241.4	290.4	221.5	262	861.8	1.1	287.7	237
3	59195.7	302	250.5	299.6	234.6	269.9	893.4	1.1	297.1	261.3
4	59279.8	316.5	239.8	319.6	206.5	269.2	922	1.1	325.2	236.7
5	60374	304.2	253.5	301.6	236.7	273	891.2	1	302	250.9
6	61524.2	317	248.9	315.8	219	274.8	921.9	1.1	311.2	245
7	63333.8	318.5	254.3	314.6	233.7	279.2	918.5	1.1	314.1	251.9
8	64119.3	321.7	254.9	317	226.1	280.8	927.5	1.1	314.9	249.7
9	65928.8	322.3	262.3	316.6	232.1	284.7	955.1	1.1	316.8	268.7
10	70529.8	334.1	269.8	333.5	248.2	294.6	988.3	1.1	334.2	276
11	71666	347.1	264.3	342.3	229.6	296.7	982.3	1.1	342.1	267.3
12	72423.5	334.8	277.8	333.6	236.5	298.8	1013.1	1.1	328.5	273.6
13	73124.9	348.4	269.4	343.7	220.4	299.1	1014.1	1.1	341.7	270
14	74317.2	350.4	271.5	345.3	247.6	302.1	1009.9	1.1	342.8	269.7
15	75986.5	348	280	343.7	256.7	306.2	1027.3	1.1	343.6	290.3
16	76210.9	362.9	268.9	353.4	254.9	305.9	1014.1	1.1	351.9	275.4
17	76996.5	360.6	273.1	353	243.5	307.6	1015.4	1.1	353.2	265.4
18	78932.2	346.1	290.9	339	282.5	312.9	1011.2	1	337.5	293.7
19	82369	373.5	282.1	366.1	254.7	318.4	1056.6	1.1	366	281.3

20	82383	366.8	287.8	363.8	258.5	318.4	1060.6	1.1	364	292.3
21	82495.2	363.4	289.8	358.4	270.1	319.2	1045.3	1.1	358.8	293.5
22	84066.3	372.4	289.6	365.2	259.4	321.8	1089.8	1.1	364	290.9
23	96270.1	411.3	299.4	407.9	259.8	343.2	1194.1	1.2	412.6	301.4
24	96466.5	400.9	307.9	396.7	265.9	344.4	1153.7	1.1	394.4	305.9
25	107408	435.8	316.4	421.1	270.1	362.5	1238.4	1.1	418.6	321.7

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	38701.6	243.2	203.2	242	191	217.7	709.1	1	243.2	207.9
2	46108.1	277.6	213.1	267.8	176	236.9	796.5	1.1	263.4	202.7
3	53220	289.5	235.1	282.1	217	255.3	838	1	280.1	228.2
4	54286.1	296.1	234.3	290.9	221.8	258.4	846.2	1	289.6	236.2
5	55576.6	305.2	232.6	302.7	206	260.5	859.3	1.1	302.5	237.2
6	55927.3	297.8	240.5	290.4	210.1	261.9	878.9	1.1	290.6	238.8
7	63011.1	319.6	252.4	310.9	221	278.4	926.4	1.1	312.1	248.2
8	63628.3	334	244	330.4	213.5	279.2	942.6	1.1	331.1	253.3
9	64385.8	326.1	253	321.1	229	281.1	948.6	1.1	320.5	251.9
10	65494	323.9	258.9	320.1	229.2	283.8	947.3	1.1	317.3	252.4
11	65508	332.7	252.3	322.6	209.7	283.1	943.6	1.1	320	240.6
12	67205.3	332.4	259.5	324.8	217.7	286.8	973	1.1	318.5	255.9
13	70810.4	338.1	268.4	331.3	236	295	994.7	1.1	331.5	265.9
14	73096.8	344.3	272	336.7	236	300	1001.4	1.1	336.8	266.5
15	73980.6	357.5	266.6	343.4	239.7	300.2	1038.7	1.2	341.8	267
16	80110.5	371	276.3	365.2	247.2	313.3	1044.3	1.1	364.5	273
17	83855.9	356.3	300.8	354.5	274.7	322.1	1061.8	1.1	344.8	296.7
18	86787.6	373.3	297.4	372.7	281.4	327	1081.3	1.1	373.3	301.6
19	91542.9	388.9	301.2	381.4	259.8	335.9	1123.3	1.1	380.9	296.7

20	95204	399.6	305.1	392.5	258.5	342	1150.6	1.1	389.8	297.1
21	103242	407.3	324.2	403.4	304.8	356.9	1192.6	1.1	400.8	326.2
22	105150	420.9	320.6	414.5	288.1	358.6	1240.1	1.2	415.3	322.5
23	107997	435.2	317.1	427.6	279.1	364.3	1217.1	1.1	427.2	317.5
24	112654	437.2	330.6	430.5	299.9	372.3	1313.5	1.2	430.7	347.2
25	117311	437.7	344.6	437	288.4	380.1	1336.9	1.2	435.3	347

G.bisphericus.P.sicanus 871A 1H 1 124-126 Hole 4

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	39964.1	250.9	203.7	249.8	183.5	221.2	732.5	1.1	247.9	202.2
2	41254.6	251.4	210.2	247.3	182.9	224.8	737.2	1	245.2	207.1
3	48043.9	280.9	218.5	279.5	202.3	242.7	796.1	1	280.9	224.9
4	49152	279.6	224.9	278.4	208.5	245.2	807.3	1.1	279.5	229.1
5	51158	288.9	226.7	283.4	213.5	250.4	825.2	1.1	282.9	233.5
6	51677	295.6	223.8	284.7	198.1	251.3	843.3	1.1	281.6	219.8
7	52476.5	299.3	224.6	296	203.8	253.6	842.3	1.1	296.5	226.2
8	54833.1	297.9	235.3	293.7	216.1	259.4	851.3	1.1	292.2	234.7
9	56053.5	304.8	236	300.1	200.2	261.8	881.2	1.1	298.4	231.1
10	56965.3	303.7	240.2	295.3	213.8	264	883.8	1.1	292.1	234.6
11	58396.1	314.1	238	309.2	221	267.3	885.9	1.1	309.5	240.4
12	60247.7	318.6	241.9	311.6	209.9	271.8	901.9	1.1	311.5	240.8
13	60893	316.3	247.7	305.7	214.3	273.6	920.1	1.1	301.7	241.7
14	61047.3	318.9	245.5	321.1	230	273.2	930.8	1.1	313.9	248.3
15	65508	329.6	253.9	323.3	224.7	283.7	933.3	1.1	323.6	250
16	66265.5	319.8	265	313.2	235.2	285.8	946.4	1.1	311.2	258.6
17	69183.2	340.8	260.6	332	236.7	291	983.9	1.1	332.6	270.8
18	70614	351.3	258.2	342.9	218.4	293.3	1024	1.2	342.1	254.4
19	72171	342.5	270.1	336.7	236	297.5	999.6	1.1	331.8	263.8

20	75916.3	347.6	279.8	346.9	248.1	305.4	1024.3	1.1	346.9	281.9
21	77950.3	350.4	285.2	347.4	248.3	310	1045.4	1.1	344.6	277.2
22	99987.4	412.6	310.5	409.3	282.5	350.4	1183.2	1.1	410.6	313.8
23	103564	424	312.8	418.6	292.1	356.6	1190.5	1.1	419.3	323.9
24	111378	440.3	324	434.3	295.9	370.4	1243.8	1.1	432.6	323.5
25	115249	449.9	328.3	444.6	296.7	376.3	1277.3	1.1	441.9	330.4

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	41366.8	259.7	205.3	252.7	187.3	224.2	760.7	1.1	249.7	212.2
2	43751.5	268.3	212	260.2	196	230.3	789.8	1.1	259.9	220.6
3	44985.9	279.6	206.9	275	184.5	233.5	790.8	1.1	274	211
4	49166.1	276.9	227.5	274.7	214	245.8	807.1	1.1	272.9	230.6
5	49741.2	279.3	229.6	274.7	207.8	246.2	828.1	1.1	270.6	235.3
6	54145.8	298.9	235.1	294.2	208.5	256.1	887.2	1.2	293.6	245.3
7	54426.4	316.9	222.5	312.8	176.1	255.8	895.9	1.2	310.9	227.5
8	55885.2	294.1	246.9	290.2	231	261.3	890.7	1.1	285.7	250.9
9	64133.3	327.5	253.5	321	226.7	278.8	969	1.2	319.9	261.2
10	64890.8	334.4	254.2	333.5	229	281.1	981.2	1.2	335.8	266.3
11	66349.7	315.8	272.4	321.3	252.5	286.7	961.8	1.1	318.3	283.2
12	66952.8	344.5	253.9	333.6	198.5	283.9	1013.3	1.2	330.2	262.6
13	72830.3	362	259.8	349.4	202.3	297.7	1019.3	1.1	346.9	257.1
14	75130.8	335.4	291.3	330.9	268.5	303.6	1046.9	1.2	335	301.9
15	77627.7	361.1	281.3	356.6	251.6	306.9	1079.1	1.2	360.8	291.9
16	80489.3	384.9	269.9	372	203.1	312.3	1084.7	1.2	365.6	269.4
17	85819.7	390.6	282.9	383.2	258	323.3	1101.6	1.1	383	289.3
18	86142.3	376.9	296.9	372	270.1	325.3	1113.1	1.1	366.8	306.6
19	88134.2	386.1	296	378.3	254.7	330.4	1113.3	1.1	371.3	285.8

20	94152	382.6	319.7	377.8	299.1	340.7	1158	1.1	380.4	332.4
21	120187	460.6	341.9	451.8	282.1	386.8	1339.8	1.2	449.4	338.3
22	128996	425	396.3	427.8	366.9	400.3	1365.7	1.2	437.3	402.2
23	138451	502	357	488.3	293.8	413.4	1415.3	1.2	491	357.3
24	147625	524.2	361.9	513.5	288.5	424	1467.6	1.2	513.1	364.2
25	155326	512.3	390.5	499.2	327.6	436.9	1494	1.1	497.9	398.3

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	37270.8	235.9	203.7	236.5	191	212.8	718.5	1.1	235.5	214.3
2	43400.8	262.7	214.8	256.3	184.5	230.3	788.6	1.1	252	222.4
3	47328.5	274.2	225.4	276.2	208	241.6	815.9	1.1	275.9	230.7
4	52729	309.3	221	301.3	180.7	252.2	877	1.2	300.4	224.4
5	55029.5	301.3	237	290.7	198.5	261.1	868.1	1.1	289	232.9
6	55239.9	297	239.2	292.8	213.7	260.3	870.3	1.1	289.1	239.3
7	55436.3	298.8	241.7	293.8	216.7	259.8	898.3	1.2	292.4	252.6
8	55548.5	323.2	222.2	311.6	184.1	258.6	901.8	1.2	310.7	226.6
9	59013.3	307.3	245.8	299.1	221	269.3	884.5	1.1	299	248
10	59195.7	322.3	237.1	310	187.3	268	921.6	1.1	305.9	233.5
11	59953.2	321.6	240.5	310.6	202.7	270.2	918.5	1.1	311.2	246.1
12	63249.6	331.4	246.1	323.6	202.3	278.5	934.6	1.1	326.6	246
13	64161.4	329.5	253.8	324.7	230	281.8	955.4	1.1	324.8	258.5
14	64904.8	328.7	257.1	317.5	225.5	280	979.6	1.2	317.3	271.2
15	74639.8	347.8	283.1	340.1	255.6	303.6	1063.9	1.2	341	293.7
16	77852.1	369.1	275.1	353.6	225.8	307.7	1073.8	1.2	348.6	288.1
17	80811.9	371.5	282.2	360.7	222.5	316.3	1072.6	1.1	357	280.4
18	82369	359.8	296.7	359.2	268.5	318.9	1084	1.1	355.6	311.8
19	83126.4	378.9	282.5	363.6	227.8	319	1085.7	1.1	356.3	278.3

20	84655.4	388.6	284.7	382.7	258.9	324.4	1108.6	1.2	384	292.4
21	84725.6	388.4	291.3	387.6	254.7	323	1152.9	1.2	389.5	311.6
22	98893.2	417.9	305.4	399.5	232.7	346.8	1212.6	1.2	395.4	296.7
23	102414	396.1	332.2	387.4	304.8	355.3	1243.6	1.2	386	337.7
24	104925	408.4	335.2	411.1	315.1	362.2	1223.6	1.1	404.5	352.1
25	118307	453.4	335	450.8	290.2	380.6	1300	1.1	448.3	339.1

G.connecta.trilobus 872C 13H 4 78-80 Hole 3

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	35769.9	247	186.6	243.9	169.6	208	705.9	1.1	243.4	189.6
2	37817.9	252	193.5	244.6	172.9	214.1	713.4	1.1	242.5	199.1
3	42713.5	260.7	209.9	254.9	191	228.5	754.6	1.1	254.9	209.3
4	42755.5	270	205.1	260.2	159.3	226.9	784.1	1.1	257.1	206.6
5	42839.7	268	208.2	263.6	190.9	229.7	772.6	1.1	264.9	210.3
6	49825.4	301.9	213.7	286.2	168.2	244.3	850.7	1.2	283	214.4
7	50007.7	297.1	216.3	289.3	173.3	246	840	1.1	289	211.8
8	50274.2	292.9	222.1	295.5	188.2	246.8	868	1.2	280.6	226
9	52139.9	296.3	227.7	285.8	199.1	251.6	860.6	1.1	281	232.6
10	54959.4	304.7	234.3	295.6	198.3	257.9	895.1	1.2	294.4	241.4
11	56362.1	311.9	235.2	306.3	202	261.6	911.2	1.2	306	246.5
12	60780.8	321.8	243.7	314.4	206	273.1	923.5	1.1	316.2	243.5
13	66728.4	342.9	250.9	330.3	202	285.1	972	1.1	326.5	247.9
14	70123	353.3	257.7	340.7	211.4	291.6	1013	1.2	338	263.6
15	71259.2	341.5	270.2	334.5	241.1	294.9	998.1	1.1	335	283.6
16	76112.7	341.4	288	337	273.2	306.4	1033.7	1.1	340.6	302.5
17	76673.8	362	274.2	350.3	236.7	307.1	1045.1	1.1	343.8	278.3
18	76968.4	356.7	278.2	349.9	254.8	306.5	1043	1.1	341.5	285.6
19	81681.6	370.1	282.7	361.1	237	316.6	1059.8	1.1	370.2	276.2

20	82523.3	365.5	290.8	356.3	240.9	318.2	1115.6	1.2	346.9	288.6
21	83673.5	387.7	279	369.6	207.7	318.7	1133.4	1.2	370.6	288.5
22	85595.3	376.9	294	363.8	265.1	324.3	1095	1.1	363.9	302.4
23	94727.1	410.5	297.1	404.8	263.7	339.8	1157.2	1.1	405.6	303.3
24	99300	416.3	307.4	402.9	250.6	348	1186.9	1.1	400.3	312.2
25	105234	429.6	314.2	422.2	262.2	359	1224.4	1.1	422.5	322.2

G.connecta.trilobus 872C 13H 4 78-80 Hole 4

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	42811.7	264.9	210.4	262.8	187.3	227.4	786.3	1.1	257.8	217
2	43134.3	262.8	213.9	265.1	187.9	229.1	788.3	1.1	256.6	222.4
3	44775.5	269	217.2	265.5	199.1	235	788.8	1.1	261.3	224.6
4	47637.1	278.6	221.8	275.5	199.5	241.2	818.4	1.1	274.3	231.3
5	48478.7	292.5	217.7	286.6	188.2	244.5	835.7	1.1	288.4	223.3
6	54159.8	300	233.5	296.3	202	256.8	869.5	1.1	293	243.4
7	56151.7	316.4	229.9	304.9	169.2	260.1	913.2	1.2	300.8	231.3
8	57175.7	307.7	239.3	301.5	214.7	263.8	882.2	1.1	296.7	240.2
9	57217.8	303.1	243.3	297.4	221.5	265.2	881.8	1.1	296.4	247.1
10	58368.1	310.7	242.6	298.2	212.6	266.7	911.3	1.1	298	246.9
11	59434.1	318.3	241.4	308.6	203.1	268.6	918.5	1.1	306.9	247.7
12	63389.9	330.5	247.7	320.3	210.9	279	937.6	1.1	318.4	247.2
13	64175.4	323	256	319.2	226.7	280.2	944.5	1.1	322	258
14	71119	346.5	265	334	221.8	295.3	1004.8	1.1	331.9	263.9
15	73798.2	357.7	266.1	342	209.8	299.5	1020.8	1.1	336.9	258.5
16	73994.6	354.9	267.3	342.9	218	300.9	1005.4	1.1	339.8	270.5
17	77136.7	352.1	284.3	355.5	244.6	306.9	1063.5	1.2	354.2	294.8
18	77599.6	354	283.8	342.3	254.7	308.9	1059.7	1.2	344.4	290.5
19	77838.1	367.2	276	367.4	245.5	307.1	1075.2	1.2	367.8	283.3

20	78581.6	355.2	285.5	344.3	249	311.9	1035.5	1.1	344.1	284.5
21	85426.9	378	291.3	367.9	236	323.4	1098.4	1.1	362.7	286.3
22	90098.1	399.2	289.9	393.3	265.9	332.4	1124.1	1.1	394.2	305
23	112388	434.6	332.6	420.5	267.2	371.6	1279	1.2	413.2	319
24	117452	447.9	339.2	437.3	299.9	379.6	1318.4	1.2	426.4	342.5
25	150556	511.3	384.8	493.8	339.4	430.7	1507.3	1.2	492.5	402.6

G.tenella 871A 1H 1 124-126 Hole 1

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	20676.4	178.9	149.9	179.5	134	157.2	542.8	1.1	176.1	153.8
2	20957	180	149.9	183.7	142.6	159.3	534.4	1.1	185	158.5
3	21027.1	175.3	154	178.1	142.6	160.2	523.7	1	179.2	154.7
4	21041.1	172.7	157.4	177.1	140.2	159.2	536.8	1.1	180.9	169.7
5	21265.6	181	151	179.8	140.2	161.9	533.2	1.1	179.4	155.2
6	21490	185.5	149.4	180.4	132.8	163.2	540.4	1.1	176.4	148.8
7	21532.1	178.2	156	177.5	145.7	161.7	537.7	1.1	184.2	162.6
8	21924.8	190.2	148.1	183.9	131.9	164.6	544.1	1.1	183.9	150.5
9	22051.1	173.5	164.2	176.7	149.2	164	550.2	1.1	179	170.6
10	24211.3	190.2	164.4	189.1	149.2	171.3	570.9	1.1	190.6	167.8
11	24225.3	193.5	161.5	190.3	150.6	172.3	582.7	1.1	191.2	165.3
12	24351.6	192.7	163.7	194.8	149.2	172.5	581.1	1.1	194.9	173.3
13	25529.9	198.4	167.5	201.6	158.9	176.3	604.1	1.1	210	173.6
14	25796.4	194.6	172.3	197.4	157.2	176.8	596.7	1.1	202.4	180.2
15	26553.9	193.8	176.7	196.4	166.2	180.1	599.3	1.1	198.8	183.5
16	26820.4	210.3	163.5	208	146.5	180.1	601.8	1.1	203.5	165.8
17	27297.3	209.3	167.6	208	153.6	181.7	608.3	1.1	205.6	172.5
18	27605.9	217.4	162.8	216.1	157.2	183.9	615.5	1.1	219.2	173.5
19	28223.2	206	176.2	215.1	152.8	185.7	627.2	1.1	213.5	187.3

20	29387.4	216.7	173.7	218	164.7	189.4	624.8	1.1	218.1	183.4
21	29724.1	208.7	183.1	212.2	168.2	190.9	638	1.1	209.4	185.4
22	29920.5	216.4	178	210.9	159.1	191	645.9	1.1	209.6	183.1
23	35054.5	215	211	226.4	187	206.8	706.3	1.1	226.6	215.6
24	36793.9	233.8	203.5	241.6	164.3	213.3	725.9	1.1	221.3	197.7
25	41927.9	260.4	209.1	263.1	189.5	226.4	794.9	1.2	263.2	227.2

G.tenella 871A 1H 1 124-126 Hole 2

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	16959.1	160.2	135.6	161.7	130.8	144.1	469.6	1	161.6	139.5
2	17155.5	156.2	142.6	156.4	130.7	143.9	481.8	1.1	157.3	148.9
3	17955.1	160.5	144.2	162.8	133	148.3	491.7	1.1	162.8	150.6
4	18586.3	167	143	169.2	137.5	150.8	497.1	1.1	169	150.4
5	18965.1	171.5	142.1	172.8	131.7	151.3	499.9	1	172.9	149.2
6	21630.3	186.4	149.1	189.1	142.4	162.8	543.6	1.1	190.1	152.8
7	21868.7	176.4	159.7	175.6	147.4	164	541.7	1.1	175.5	161.2
8	21910.8	182.7	154.2	177.7	143.5	163.2	533.5	1	178.1	157.8
9	22317.6	187.3	153.1	191	147.4	164.3	550.2	1.1	192.5	161.6
10	25024.9	202	159.3	202.2	149.5	174.3	587	1.1	202.5	166.1
11	25235.3	204.6	158.5	206.8	149.8	174.4	588.9	1.1	206.6	168.4
12	25824.5	189.8	176.6	193.1	165.2	177.1	597	1.1	194.5	179.8
13	26020.8	187.4	180.1	194.8	167.7	178	600.1	1.1	199	183.7
14	27577.9	204.3	173.8	199.1	156.8	183.6	611.9	1.1	198.6	179.4
15	27605.9	197.9	180	202	158.9	184.5	615.3	1.1	198.1	181.3
16	28012.7	211.7	170.1	209.4	157.2	185.3	617.6	1.1	206.8	177
17	28419.5	207.4	176.7	211.7	164.3	186.9	625.6	1.1	212.9	190.1
18	28952.6	220.8	168.5	218.4	138.6	187	627	1.1	214.6	170.1
19	29078.8	216.9	173.1	213	154.7	187.8	633.2	1.1	210.7	173

20	35924.2	245.1	189.9	246.3	171.5	209	716.5	1.1	246.9	202
21	35952.3	231	201.9	233	178.4	209.4	709	1.1	228.5	205.2
22	36260.9	248.2	189.9	244.2	164.7	208.8	727	1.2	244	190.9
23	36948.2	238.3	200.2	245.8	188.1	213.1	725	1.1	243.6	217.4
24	37537.4	252.3	191.9	244.9	169.2	213	729.9	1.1	241.1	197.1
25	39150.5	238.9	213.2	246.5	185	219.4	745.5	1.1	238	226.4

G.tenella 871A 1H 1 124-126 Hole 3

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	18375.9	171.6	138	171.9	134.5	150.1	498.7	1.1	175.3	145.7
2	22794.5	178.3	164.8	183.2	149.9	166.5	552.1	1.1	182.1	163.9
3	22962.9	193.5	152.7	189.5	138.6	167	555.9	1.1	187.3	153.7
4	23243.4	198.3	153.8	205.2	129.3	169.7	622.3	1.3	207.9	163.8
5	24043	179.4	173.4	183.7	154.1	170.5	575.7	1.1	183.6	182
6	24183.3	183.8	169.7	190.3	157.3	173.1	570.5	1.1	193	178
7	24267.4	196.8	158.8	192	146.3	172.3	573.9	1.1	187.6	162.1
8	25207.3	191.5	170.4	194.8	151.7	175.1	596.4	1.1	199	183.6
9	25824.5	187.3	177.6	194.6	155.8	178.4	614.5	1.2	188.4	186.8
10	25880.6	193.8	173	201.7	158.9	177.1	601.5	1.1	196.2	172.3
11	26750.3	193.8	178.4	197.7	158.9	181.2	605	1.1	197.4	187.7
12	27788.3	204.9	175.1	200.5	160	183.8	623.1	1.1	197.8	176.1
13	27788.3	197.1	181.6	215.6	164.2	184.6	701.2	1.4	199	185.5
14	27900.5	197.6	183.2	202.7	165.8	183.6	660.1	1.2	204.8	187.9
15	28587.9	220	167.4	215.6	146.5	185.9	634.3	1.1	213.9	170.6
16	28826.3	206.2	181	209.8	165	188.3	632.4	1.1	209.5	192.5
17	29499.6	203.3	188	205.2	172.7	189.5	638.3	1.1	201.8	191.3
18	30663.9	222.3	178.7	225.8	169.5	192.8	666.8	1.2	227.4	192.2
19	32403.3	217.6	193.3	224.8	180.7	198.4	673.2	1.1	226.9	202.9

20	33104.7	224.7	190.1	228.5	164.2	201.1	685.7	1.1	220.2	195.1
21	33848.1	231.6	188.8	233.6	171.6	203.4	692.7	1.1	231.7	200.2
22	34521.5	236	189.7	240.8	166.9	205.7	712.2	1.2	237.8	210.8
23	38266.8	246	200.7	248.6	186	216	758.1	1.2	250.9	213.3
24	42390.8	243.9	224.4	251.1	210.6	228	765.4	1.1	256.6	233.3
25	55997.4	298.5	243.4	307.1	222.5	261.4	913.9	1.2	304.8	262.2

G.tenella 871A 1H 1 124-126 Hole 4

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	13732.8	136.6	129.6	137.8	116.3	128.1	426.4	1.1	138.3	131.7
2	18432	158.1	150.1	161.1	139.9	149.4	493.3	1.1	162.5	153.4
3	21995	181.2	156.4	186	144.6	163.4	542.5	1.1	183.9	161.3
4	24099.1	190.2	163.2	192.8	154.1	172	567.6	1.1	194.2	173.4
5	24169.2	199.3	155.8	194.3	129.8	171.6	576.2	1.1	195.5	154.1
6	24744.4	188.5	169.8	196.2	161.1	173.2	591	1.1	196.2	181.9
7	26245.3	203.8	165.9	203.8	153.6	178.9	598.3	1.1	206	172.5
8	26315.4	199.7	169.6	199.4	155.4	178.6	606.4	1.1	195.8	172.8
9	28139	200.4	181.3	207.8	164.2	184.9	636.7	1.1	211.3	191.8
10	28307.3	222	164.4	214.9	137.4	184.4	630.1	1.1	213.1	159.4
11	28615.9	211	174.4	211.4	162.1	186.3	635.4	1.1	208.4	186.2
12	29387.4	196	193.9	198.6	180.9	189	631	1.1	200.9	196.9
13	30481.6	209.1	187.5	217	165	192.3	652.5	1.1	209.3	190.4
14	30860.3	228.4	175	225.5	152.8	194.5	664.4	1.1	228.4	179.6
15	31407.4	230.7	175.4	224	149.9	194.7	665.2	1.1	216.8	175.5
16	32557.6	220.4	190.8	228.3	171.8	198.9	703.2	1.2	216.3	192.3
17	33048.6	223.9	190.3	233.1	162.5	202.2	682.3	1.1	230.3	202.6
18	37298.9	239.5	201.5	243.6	183.9	212.8	727.8	1.1	243.7	213.4
19	37467.2	242.9	198.7	249	192.6	213.9	729.3	1.1	248.5	207.5

20	38168.6	253.6	194.9	255.8	176	215.3	741.3	1.1	253	199.4
21	39781.7	248.4	209.6	248.4	187.9	221.1	799	1.3	246.2	225.9
22	41072.3	274.6	192.2	268.1	179.2	222.8	760.8	1.1	268.8	201.5
23	42040.1	259.1	210.5	268.1	191	225.9	788.2	1.2	268.2	227.7
24	43891.8	263.3	216	268	199.4	231.4	793.6	1.1	264.5	230.4
25	55043.6	272.2	262.3	280.7	232.7	259.6	904.4	1.2	279.9	273.2

T.truncat.excelsa.pachytheca 871A 2H 124-124 Hole 1

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	127790	427.8	382.3	440.9	364.6	398.8	1306.9	1.1	437	390.7
2	127972	425	385.2	434.5	369.8	399.3	1301.3	1.1	428.5	391.5
3	136248	446.7	391.2	448.3	362	412	1350.8	1.1	443.4	393.1
4	144104	465.6	397.1	488.1	381.4	423.3	1401.8	1.1	473.9	406.6
5	157121	492.9	409	499	398.9	441.7	1457.5	1.1	497.1	421.3
6	160866	484.1	425.9	489.5	401.3	447.9	1468.8	1.1	477.3	426.1
7	161820	497	417.1	500.8	390.4	448.4	1511.6	1.1	500.1	428.1
8	162970	493.3	423.1	505.9	413.7	450.4	1480	1.1	499.7	435.6
9	163588	488.9	427.5	490.8	413.4	452	1461	1	483.1	427
10	165552	483.7	438.4	502.4	415.5	454.3	1527.4	1.1	483.3	436.2
11	166533	501.4	424.9	498.9	405.8	455.7	1483.1	1.1	493.4	427.1
12	166870	494.6	431.4	500.5	409.5	456.4	1486.3	1.1	485.2	436.4
13	169115	499.3	435.5	505.5	399.3	459.1	1534.7	1.1	494.9	435.4
14	178695	512.5	445.3	510.9	429.8	472.5	1525.9	1	512.5	453.6
15	194167	530.3	469.8	544	442.4	492.4	1622.4	1.1	545.4	476
16	194799	537.6	464.5	537	439.7	492.7	1631.7	1.1	532.1	470.2
17	202682	529.1	492.4	558.9	448	502.8	1685	1.1	523.4	494
18	221689	572.3	495.9	568.5	457.4	526.5	1746.9	1.1	558.7	511.2
19	228969	575.3	516.2	577.4	460.9	535.4	1827.9	1.2	583.6	525.6

20	241047	642.2	483.9	650.1	460.4	546.2	1863.2	1.1	645.2	506.6
21	152492	482.7	405.2	493	389.4	435.8	1426.6	1.1	492.7	411.4
22	153193	482.5	407.6	483.6	384.4	436.6	1438.9	1.1	476.9	418.2
23	169115	507.1	428.7	524.6	394.4	458	1559.5	1.1	508.8	440.3
24	176647	508.8	444.4	504.6	419.7	469.4	1546.3	1.1	504	442.5
25	177671	524	435.9	530.3	415.9	470.1	1570.7	1.1	527.3	459

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	93576.9	379.9	315.6	389.5	302.3	340.3	1128	1.1	379.7	323
2	117928	434.1	348	434.9	340.2	382.3	1256.6	1.1	433.3	355.8
3	124634	452.7	352.6	445.2	336.9	392.5	1300.4	1.1	446.6	361.3
4	126345	460.2	352.2	454.7	333.7	394.6	1320	1.1	461.3	359.9
5	127383	451.8	361.4	448.9	343.5	397.1	1316.3	1.1	447.2	371.7
6	135561	465.9	373.1	472.1	359.7	409.7	1365.1	1.1	469.4	384.6
7	140022	467.3	383	466	372.9	417.1	1359.2	1	465.7	389.3
8	148312	480	397.9	492.9	373.1	429	1446.5	1.1	483.3	404.3
9	153923	486.5	407.6	494.4	371.8	437.3	1606.1	1.3	485	426.9
10	156756	515.6	395.7	517	385.3	445.6	1521.7	1.2	511	411.8
11	157724	517.8	391.4	521.2	383.7	440.7	1479	1.1	517.3	404.7
12	157808	511.5	396.9	524.6	371.9	441.2	1552.2	1.2	528.2	406.4
13	160600	487.3	421.8	490.4	405.5	447.7	1472.6	1.1	493.9	441.9
14	164962	493.7	427.8	503.7	407.7	453.3	1487.9	1.1	502.6	433.9
15	171233	495.8	442.2	511.3	414.5	462.3	1519.1	1.1	495.6	451.4
16	177040	533.9	424.8	534.5	412.2	468.9	1562.9	1.1	525.8	430.6
17	177643	523	436.6	537.1	415.3	469.7	1578.6	1.1	520.4	441.4
18	182062	517.9	450.6	544.1	431.7	476.6	1584.2	1.1	524.9	460.7
19	182342	537.2	435.1	537.8	417.5	476	1582.9	1.1	539.5	451.3

20	191881	573.8	430.3	570.2	401.9	486.9	1664.8	1.1	562.3	443
21	195177	531.1	470.6	543.1	443.1	493.8	1654.4	1.1	529.7	480.1
22	197787	558	454.7	558.2	440.4	496.1	1632	1.1	556.7	469.1
23	199582	559.9	458.1	576.8	432.8	498	1759	1.2	567.3	480.5
24	206989	574.9	462	583.2	438.5	507.3	1688.1	1.1	575.4	474.1
25	210523	580.8	464.3	578.2	437.9	511.3	1700.1	1.1	569	472.1

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	79297	366.1	278.1	373.5	266.2	312.2	1067.8	1.1	359.8	289.3
2	83350.9	359.9	297.8	366.1	284.4	321	1060.8	1.1	362.3	303.8
3	97883.3	389.5	323.2	397.3	291.7	347.3	1164.1	1.1	387	328.7
4	113398	414.3	352.2	428	328.2	374.5	1308	1.2	423.6	388.6
5	113580	416.5	349.5	424.6	328.5	375.3	1237.9	1.1	422.1	360.2
6	121926	434.8	360.4	442.9	337.6	388.7	1298.4	1.1	435.4	371.6
7	132335	447.6	379.4	457.6	351.8	405.6	1348.9	1.1	445.4	387.2
8	139124	458.6	388.8	463.2	362	415.9	1379	1.1	463.8	393.4
9	142715	476.8	383.9	476.1	360.5	420.4	1398.1	1.1	466	390.5
10	147989	474.2	399.9	482.3	379.2	429.3	1427	1.1	479.3	406.8
11	155845	491.1	406.6	491.4	386.7	439.8	1466.3	1.1	487.2	407.1
12	168161	509.3	423	510.6	395.5	457.5	1499.2	1.1	507.9	424.1
13	170517	497.8	440.3	503.1	397.1	459.5	1701.4	1.4	503.2	435.7
14	172720	505	439	514.2	399.9	464.1	1656	1.3	508.8	485.2
15	178864	518.4	443	537	418.8	472.3	1583.5	1.1	519.8	455.5
16	181908	524.3	443.6	528.9	428.8	476.5	1567.1	1.1	515.1	443.3
17	181992	526.8	441.9	527.1	425.7	476.3	1553.7	1.1	524.4	453.3
18	183970	582.2	410.3	588.6	391.3	476.9	1642.7	1.2	583.6	426.6
19	188907	534.6	452.8	554.5	434.6	485.6	1599.5	1.1	535.7	458.8

20	194041	561.2	442.5	558.5	430.2	490.6	1621.3	1.1	553.2	448.9
21	206161	575.7	458.6	568.3	438.9	505.9	1686.4	1.1	565.7	470.4
22	223906	585.9	489.8	606	468.2	528.4	1807.6	1.2	583.5	498.7
23	253503	660.3	493.1	646.8	451.3	560	1912.1	1.1	646.7	498.7
24	254738	643.2	508.7	642	481	562.5	1890.3	1.1	630.7	522.8
25	298475	669.9	572.6	693.2	544.9	610.1	2065.8	1.1	660.7	580.7

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	103971	408.1	328.6	459.1	307.3	358.2	1389.9	1.5	450.3	336.7
2	106805	394.9	346	398	324.1	364.3	1187.6	1.1	387.4	348
3	115053	429.5	343.8	432.7	328.3	377.1	1270.5	1.1	425.6	348.8
4	115754	423.3	350.9	414.6	333.9	378.8	1255.8	1.1	417	355.4
5	127285	458.2	356.4	460.7	346.2	396.5	1329.6	1.1	448.6	363.3
6	133022	455.3	374.5	461.3	358.3	406.6	1341.4	1.1	451.7	380.7
7	137539	448.5	392	454.3	379.2	414	1342.5	1	450.4	402.9
8	140597	467.4	385.8	474.5	376.7	417.9	1410.9	1.1	483.9	397.3
9	144146	472.6	390.6	477.8	375	423.4	1397.7	1.1	474.7	402.8
10	154414	482.8	408.5	479.5	392	438.6	1424.9	1	478	414
11	156139	495.6	404.5	516	380.2	440.1	1470.1	1.1	497.2	415.1
12	158355	481.1	420.5	481.6	397	444.9	1444.3	1	476.7	432
13	177994	524.8	434.5	544.6	427.2	471	1716.4	1.3	537	442.3
14	187575	539.5	445.9	550.9	425.4	483	1594.3	1.1	544.8	456
15	188150	535.9	451	542.2	427.1	483.9	1701	1.2	541.2	494.2
16	193592	548.2	451.8	546	434.7	491.3	1627.7	1.1	543.4	475.1
17	194308	557.7	446.3	561.9	427.4	491.2	1654.2	1.1	552.2	466.2
18	195500	560	449.7	576.6	425.5	492	1664.6	1.1	570.3	469.4
19	200410	556.6	462.5	567	440.5	499.1	1682.6	1.1	551.6	472.2

20	200480	544.1	472.5	570.8	457.4	500.1	1650.7	1.1	563.7	491
21	203678	570.5	458.6	567.3	439.2	503	1686	1.1	556.8	471.3
22	209051	599.8	453.6	601.5	447.3	510.5	1743.6	1.2	597.7	476.4
23	209654	586.8	458.5	585.7	445.6	509.6	1731.5	1.1	584.9	463.3
24	228044	583.3	501.9	606.3	475.4	533.7	1789	1.1	599.9	520.5
25	247542	632.8	500.8	627.3	472.6	554.8	1838.7	1.1	616.6	504.1

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	51971.6	285.9	233.1	290.2	218.2	252.4	844.1	1.1	282.4	237.1
2	61271.7	314.3	250	306.7	231	274.1	916.1	1.1	307.3	251.7
3	65423.8	315.8	265.7	334.7	251.4	284.1	1004.4	1.2	325.8	272.3
4	66111.2	320.8	264.5	315.4	238.4	285	953.5	1.1	309	264.5
5	73966.5	339.7	278.4	333.7	259.2	302.2	994.7	1.1	330.9	277
6	81401.1	366.5	283.6	364.3	278.4	316.6	1037.6	1.1	367.3	287.9
7	82803.8	354	298.9	359.1	276.4	320.1	1046.9	1.1	349.6	305.3
8	83491.1	357.8	298.3	362.3	273.8	321.7	1056.1	1.1	345.5	297.4
9	86268.6	362	304.5	361.9	287.2	327	1128.3	1.2	364.9	300.2
10	87404.8	354.2	315.5	356.3	295.4	329.4	1076.8	1.1	354.3	323.7
11	95484.6	381.6	320.2	374.9	304.9	343.9	1133.2	1.1	374.4	324.4
12	98191.9	394.2	318.8	386.6	298.3	348.7	1153.6	1.1	384.6	318.4
13	98963.4	384.4	328.7	378.4	315.3	350.8	1135.9	1	375.7	330
14	115277	424.4	347.7	421.2	331.8	377.7	1250.9	1.1	423.1	359.9
15	122824	440	357.8	436	336.4	390.3	1299.3	1.1	432.9	365
16	123455	441.2	359.3	436.2	326.7	390.6	1314.9	1.1	418.1	354.1
17	123694	424.3	372.1	429.7	359.2	393	1321.9	1.1	416.2	379.2
18	131760	446.8	377.5	444.6	361.9	404.7	1346.1	1.1	437.7	380.2
19	137904	459.6	383.8	458.8	369.7	414.1	1354.9	1.1	443.6	378.2

20	141130	462.7	389.4	471.1	368.8	419.3	1360.5	1	467	392.1
21	150893	485	399.3	495.8	379.8	432.6	1460.3	1.1	465.5	398.1
22	151258	473.7	408.6	470.9	395.3	434	1422.3	1.1	462.4	415.2
23	165720	507.2	419.1	505.6	399.9	453.4	1528	1.1	522.8	433.8
24	166730	511.8	418.2	545.2	404.8	454.9	1569.8	1.2	505.5	422.9
25	167137	483.1	443.3	500.5	407.9	456.7	1501.7	1.1	494.8	458.7

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	76435.4	331.8	294.1	339	275.4	308	996.2	1	334.2	300
2	80419.1	337.7	304	337.4	291	316.3	1034.5	1.1	333.7	310.2
3	86759.5	349.3	317.9	364.2	290.1	328.2	1070.8	1.1	338.3	320
4	89326.6	355.9	320.4	354.9	311.8	333.4	1079.1	1	352	323.6
5	93548.8	366.8	325.6	366.8	302	341.1	1108.1	1	365.6	328.9
6	94264.2	372.9	323.6	386.7	293.2	342.5	1212	1.2	374.3	337.7
7	98654.8	379	333.3	399.1	315.1	350.2	1250.6	1.3	377.5	332.2
8	98767	375.8	336	379.2	321	350.3	1128.6	1	365	334.8
9	103130	396.4	333.5	401	314.7	357.5	1190.1	1.1	391.6	342.6
10	103817	393	338.2	389.3	316.5	359.1	1184.6	1.1	385.8	337.1
11	105009	393.8	341.2	404.4	327.6	361	1219.3	1.1	396	344.1
12	105135	411.3	328.9	421.5	310.6	360.5	1210.1	1.1	423.7	340.9
13	107254	401.9	341.4	402	321	364.9	1207.2	1.1	393.2	342.8
14	107520	399	344.2	401.2	334.7	365.6	1188.9	1	396.6	350
15	108250	413.4	335.9	435.2	307.5	366.4	1264.4	1.2	423.8	349
16	115207	419.8	353	411.3	314.8	377.1	1267.7	1.1	413	360.5
17	119584	416.2	367.6	416.5	341.8	385.7	1265.6	1.1	408.2	376.3
18	121127	432.4	358.3	429.8	336.4	388.1	1272.8	1.1	414.7	358
19	129824	431	385.4	435.5	365.1	402	1324.1	1.1	419.7	385.4

20	138984	465.5	383	463.5	355.3	414.9	1387.1	1.1	461.2	396.8
21	144623	472.5	391.9	471.7	370.7	424	1396.4	1.1	472.4	405.3
22	145969	450.6	416.8	473.3	391.6	426.2	1458.7	1.2	451.1	422.9
23	148592	473.5	402.9	466	361.1	429.3	1425.7	1.1	457.9	400.8
24	152338	487.4	400.4	487.6	375	435.1	1461.6	1.1	485.2	411.5
25	166071	504.6	421.5	497.6	390.4	454.1	1556.9	1.2	493.8	428.4

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	55885.2	303.7	235.3	303.5	224	261.7	878.8	1.1	304.8	238.3
2	80250.8	346.1	296.4	343	278.1	315.4	1035.5	1.1	341.3	294.1
3	88639.2	369.5	306.2	366.7	296.2	331.5	1081.1	1	367	311.7
4	96368.3	386.7	319.1	395.7	305.9	345.2	1151.9	1.1	394.1	326.5
5	96705	387.2	320	402.9	308.8	346.7	1144.4	1.1	404.1	337.2
6	97266.1	387.6	320.6	382.7	317.9	347	1131.7	1	383.7	331.7
7	100913	391.4	329.5	389.3	319.4	353.8	1160.7	1.1	391.4	339.5
8	106538	409.2	333.4	420.8	321.7	363.2	1253.9	1.2	402	340.2
9	106917	405.6	338.2	415.3	319.4	363.7	1219.9	1.1	391	334.8
10	111350	408.3	348.3	405.3	337.1	371.7	1207.2	1	396.5	347
11	114590	414.1	357.3	423	330.3	382	1261.6	1.1	426.3	370.5
12	119640	431.4	356.2	468.9	338.7	385.6	1403.3	1.3	456.1	351.1
13	120636	401.6	384	406.6	364	387.9	1288.9	1.1	407.8	396.5
14	122417	415.2	377.7	421.7	369.3	393.6	1271.8	1.1	420.1	387.6
15	123147	427.5	369.5	442.3	336.3	390.9	1292.9	1.1	419.7	374.2
16	123539	432.1	367.9	425.5	340.9	393	1322.9	1.1	425.7	375.5
17	124129	431.1	367.9	438.6	351.1	393.1	1290.5	1.1	425.8	366.3
18	128140	437.4	375.4	449.2	346.3	398.6	1336.5	1.1	434.7	381.9
19	137118	468.1	375.3	464.1	366.9	412.5	1382.4	1.1	464.7	387.5

20	139853	462	387	458.3	368.4	417.3	1389.9	1.1	453.1	394.4
21	147681	477.5	397	479.5	375.4	428.3	1451.7	1.1	460.5	398.6
22	155620	496.7	401.3	495.4	388.9	439.4	1478.5	1.1	487.3	418.3
23	157556	491.9	409.8	498.6	396.6	442.9	1441	1	493.2	417.8
24	159506	482.9	424.8	492.4	403.7	449.6	1493.9	1.1	485	432.7
25	159730	492.2	414.8	484.8	394.2	446.2	1452.8	1.1	474.5	408.7

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	58494.3	307.5	243.7	296.2	225.8	267.7	882.8	1.1	300.2	244
2	62464.1	305.1	261.8	302.5	253.9	277.7	906	1	303.2	267.6
3	65774.5	320.7	262.2	313.7	241.6	284.5	944.7	1.1	314.9	267.1
4	81639.5	349.9	298	351	278.1	318.1	1097.4	1.2	348.5	315.1
5	83519.2	344.7	309.6	343.9	298.2	322	1047.1	1	342.3	315.6
6	88414.8	354.9	318.3	352.6	302.3	331.1	1078.3	1	348.1	321
7	93394.5	365	327.4	372.7	293	340.9	1109.1	1	369.4	335.6
8	96129.8	366.3	335.1	372.5	319.4	345.7	1129.2	1.1	353.3	332.4
9	97855.2	380.1	328.8	389.7	313.2	348.8	1138.9	1.1	371.8	326
10	99720.9	388.1	328.2	380.5	306.2	351.5	1148.9	1.1	373.5	321
11	105654	402.8	336.2	403.7	313.3	361.7	1200.8	1.1	387.2	325.8
12	106580	389	350.4	394.6	333.3	363.9	1201.9	1.1	385	362.8
13	106721	390.2	349.5	396	338.8	364.4	1182.1	1	386.6	354.5
14	109133	412.3	339.8	438.6	312.5	367.5	1284.8	1.2	440.9	375.1
15	122347	421.3	371.6	430.5	358	390.4	1290.7	1.1	410.7	366.8
16	124690	433.3	367.7	426.3	348.2	393.7	1280.1	1	424.4	368.9
17	125658	411.8	389.3	412.1	375	396.3	1277.9	1	410.3	396.3
18	131619	452.4	372.3	444.5	353	403.9	1331	1.1	443.6	371.4
19	132657	442.3	383.2	443	365.5	406.7	1322.3	1	437.2	389.3

20	140541	461.4	389.6	471.4	370.8	417.6	1368.1	1.1	449.4	378.5
21	143921	473.3	389.4	466.4	375.2	422.3	1407.4	1.1	467	397.1
22	148312	484.9	391.8	482.7	377	428.6	1422.1	1.1	476.2	400.3
23	148354	476.2	398.2	476.7	379.2	429.3	1400.3	1.1	459.9	392
24	161722	495.9	417.6	494.4	396.6	448.6	1484.2	1.1	477.3	422.5
25	190324	563.9	435	577.3	399	484.5	1676.7	1.2	563.1	436.2

G.nepenthes 872C 5H 6 59-61 Hole 1

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	41717.5	275.2	196	269.9	175.4	225.5	764.9	1.1	269.4	205.2
2	43274.6	285.8	193.6	279.9	179.2	228.5	765.4	1.1	278.6	193.3
3	46767.4	286.7	208.8	290.4	207.4	238.8	792.1	1.1	291	219.1
4	50232.2	315.3	203.7	309.2	196	245.8	833.6	1.1	309.3	208.8
5	56067.6	316	226.6	309.8	220.4	261.7	864.8	1.1	311.4	229.5
6	56965.3	316.5	233.5	313.9	224.8	265.3	884.7	1.1	313.6	245.1
7	58283.9	330.4	227	325.2	206.4	266.1	910.6	1.1	322.6	234.6
8	58816.9	328.8	229.2	322.1	211.1	267.2	901.9	1.1	322.2	233.8
9	59209.7	313.3	241.7	307.9	221.9	269.2	893.8	1.1	309.9	240.2
10	60486.2	334.8	230.8	327.6	210.1	271.1	900.8	1.1	327.6	228.4
11	69968.7	342.6	262.7	346.1	235.8	292.4	987	1.1	345.8	276.2
12	70389.5	340	267.4	341.2	239	293.4	992.2	1.1	349.7	278.3
13	71231.2	354.8	256.2	349.9	249	295.2	976.7	1.1	348.5	262.4
14	72297.3	341.6	273.9	346.7	247.6	298.4	1004.8	1.1	340.8	277.7
15	73321.3	350.5	267.3	347	251.9	300.1	990.2	1.1	349.3	271.3
16	75593.7	351.4	278.5	353.3	252.7	303.7	1211.1	1.5	357	308
17	75720	372.3	261	365.2	241.6	304.1	1058.3	1.2	362.4	271.8
18	77389.2	375.5	265.1	376.8	258.5	307.4	1036.7	1.1	377.6	277.4
19	77585.6	370.5	268.1	376.1	258.3	308.3	1040.9	1.1	374.8	284.6

20	80783.9	389.9	269.7	407.7	256	315.1	1101	1.2	404.4	287.2
21	80797.9	381.8	271.8	381.9	247.6	313.6	1066.8	1.1	374.5	280.9
22	84304.7	383.8	282.5	378.6	259.3	322.5	1061.3	1.1	379.2	285.4
23	99328.1	419.3	307.2	423	304.5	349.6	1175.4	1.1	428.4	323.1
24	107155	412.6	334.6	419	302.3	363.1	1222.5	1.1	419.4	356.2
25	117732	446.5	341.2	442.3	300.1	379.9	1320.5	1.2	441.9	357.2

G.nepenthes 872C 5H 6 59-61 Hole 2

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	30649.9	233	169	240.8	165.2	193.4	649.6	1.1	240.2	185.3
2	33034.6	242.2	178.3	240.2	168.2	202.6	673.8	1.1	238.1	179.4
3	37986.2	258.5	188	252.7	175.4	215.4	716.1	1.1	253.9	191.9
4	38224.7	264.4	185.3	258.3	174.4	214.5	718.3	1.1	260.8	188.1
5	40090.3	257.3	199.3	263.5	191.3	221	728.9	1.1	260.1	206.2
6	44859.7	281.4	204.2	278.4	200.2	233.1	812.2	1.2	277.8	210
7	47931.7	280.5	220.5	282.1	212	242.2	819.8	1.1	282	236.8
8	51340.3	284.8	231.7	282.1	218.1	251	833.5	1.1	282.1	247.1
9	51620.9	276.3	241.8	283.1	225.5	254.5	869.2	1.2	287	264.8
10	51873.4	292.4	227.1	295.9	210.9	252.2	860.6	1.1	296.7	229.5
11	52462.5	292.7	229.4	291.8	217.4	253	865.6	1.1	282.5	227.9
12	54833.1	315.1	222.7	324.7	209.4	258.2	879.9	1.1	325.9	223.2
13	62534.2	336	238.9	336.3	233.8	275.6	927.3	1.1	338	252.3
14	65171.3	346.4	241.4	343.8	215.6	281.1	950.2	1.1	344.2	246.7
15	70333.4	361.1	249.2	361.1	232.2	292.9	992.7	1.1	362.7	255.8
16	71231.2	362.5	254.9	352.1	240.8	297.4	998.3	1.1	352.4	261.8
17	71680.1	367.4	252.2	375.7	241.1	295.2	1012.1	1.1	379.2	259.4
18	72998.6	356.2	265.1	378.4	248.6	298.2	1071.5	1.3	378.3	290.5
19	73938.5	359.9	262.1	357.1	249	300.9	1003.9	1.1	357.5	267.1

20	74317.2	362.6	262.5	360.3	240.2	301.5	1009.9	1.1	357.6	261.3
21	81527.3	377.8	277.2	377.7	261.9	316	1077.9	1.1	380.1	292.5
22	84599.3	377.3	289.6	374.9	263.8	321.7	1098.9	1.1	376.8	306.3
23	89943.8	400.5	290	398.4	264.3	333.6	1124.6	1.1	400.2	303.7
24	98332.1	402.7	313.1	404.2	304.6	349.1	1158.6	1.1	401.2	328.7
25	102498	447.4	293.1	441.8	286.5	353.1	1202.8	1.1	438.7	307.1

G.nepenthes 872C 5H 6 59-61 Hole 3

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	30593.8	220.1	180.5	216.5	164.2	194	643.4	1.1	222.9	182.1
2	34212.9	241.9	181.7	239.8	164.8	204.1	681.9	1.1	239.8	187.3
3	39192.6	259.1	193.9	258.7	176.3	218.5	726.9	1.1	257	199.9
4	40034.2	260.6	197.7	256.4	190.9	222	729.3	1.1	257.3	202
5	40833.8	270.8	193.1	275	183.7	222.8	763.9	1.1	277.3	200.1
6	44046.1	272.9	207.5	271.3	199.4	231.6	771.7	1.1	269.3	219
7	45645.2	273.4	213.3	272.7	206	236.3	771.2	1	273.1	222.9
8	47623.1	278.3	224.2	278.4	217.7	244.1	813.9	1.1	279.9	236.4
9	48829.4	293.9	214.5	287.2	207.4	244.6	811.2	1.1	287.1	221.1
10	51705	291.5	227.1	292.5	221.2	251.7	829.3	1.1	292.9	240.1
11	52322.2	303.4	221.8	300.5	212.9	253.5	849.3	1.1	299.1	230.7
12	52336.3	288.3	232.3	286.2	222.5	253.6	832.1	1.1	288.9	240.9
13	54145.8	306.1	227.6	301.1	194.3	256.5	866	1.1	301.4	225.8
14	60836.9	329.6	236.5	321.7	229.2	273.3	915.8	1.1	321	242.2
15	61257.7	334.5	234.1	331.3	224.8	272.9	916.9	1.1	330.8	244.3
16	64427.9	329.2	251.8	327	239.5	282.6	951.1	1.1	327	266
17	67107.1	363.3	238.7	363.8	217.7	284.9	1010.1	1.2	359.9	255
18	68832.5	351.6	251	355.5	236.1	290.1	973.7	1.1	353.1	261.2
19	77613.7	386.8	257	390	239.7	306.6	1061.3	1.2	390.6	268.9

20	78960.3	378.6	268.1	370.2	251.4	310.1	1068	1.1	369	273.3
21	79086.5	371.8	276.4	374.6	257.7	313.8	1062.6	1.1	374.2	292
22	81849.9	372.5	283.1	373.1	263	316.5	1065.2	1.1	371.6	301.4
23	82747.7	387.2	273.7	392.1	246.9	317.9	1176.3	1.3	392	292.9
24	82789.8	367.7	291.6	374	284.6	323.2	1057.8	1.1	375.7	303.7
25	85469	408	270.3	408.4	267.2	322.3	1097	1.1	408.4	285.4

G.nepenthes 872C 5H 6 59-61 Hole 4

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	27886.5	222.3	160.8	214.5	139.9	184.1	610	1.1	215.4	162.8
2	30888.4	209.1	190.2	210.1	178.1	194.3	636.4	1	211.3	198.9
3	32192.9	228.6	180.7	222.6	163.8	197.5	652	1.1	222.2	180.6
4	34493.4	232.7	191.3	235.7	186	207.5	686.8	1.1	237.7	194.7
5	34633.7	234.5	189.6	234.1	176.7	205.6	681.9	1.1	232.2	194.1
6	35671.7	225.2	205.6	229.2	192.6	213	689.6	1.1	227.5	202.3
7	36148.6	247.5	186.1	243.7	178.1	210.2	686.8	1	243.4	187.2
8	39403	259.4	194	263.5	181.5	218.6	730.2	1.1	263.5	191.5
9	42096.3	256.2	212.7	256.4	183.6	227.2	791.8	1.2	252.8	215.5
10	42418.9	265.7	208	266.6	198.2	229.2	783	1.2	266.2	220.8
11	42629.3	274.4	201.5	271.8	196	229.8	765.6	1.1	272.7	206.7
12	44368.7	285.1	198.8	284.2	197.1	232.1	772.5	1.1	284.1	208.8
13	44929.8	268.1	214.4	266	201.3	234.6	793	1.1	265.9	219.3
14	46262.4	278.8	213.1	282	204.9	238.4	793.9	1.1	283	225.4
15	48717.2	305.8	211	307.1	196	246	856	1.2	307.1	228.5
16	49797.3	288	221.7	287.2	210.1	246.6	809.7	1	283.5	223.9
17	51031.7	296.3	221.4	293.1	206	250.1	828.7	1.1	294.4	228
18	51648.9	320.2	206.6	316.4	198.3	249.1	857	1.1	315.7	210.4
19	61454.1	339.2	234.6	330	222.5	275.4	937.6	1.1	330.9	243.6

20	62912.9	339.1	237.4	335.4	218.2	276.5	947.1	1.1	335.5	246.8
21	66209.4	350.3	243.6	356	232.8	284.3	994.7	1.2	359.6	251
22	71048.8	354.1	257.7	340.1	228.6	294.3	988.7	1.1	342.1	254.3
23	79521.4	357.6	285.8	354.9	273.5	312.9	1056.2	1.1	354.6	289.8
24	84837.8	404.4	270.9	408.3	258.2	322.4	1108.4	1.2	413.7	280.4
25	92426.6	430.2	280.5	423.1	251	333.8	1204.6	1.2	424.2	305.1

G.nepenthes 872C 3H 6 59-61 Hole 1

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	34100.6	231	189.4	232.8	179	204	672.8	1.1	228.8	195.1
2	36359.1	245.5	189	240.9	178.1	210.9	688.9	1	240.9	191
3	39332.9	259.6	194.2	256.9	179	218.6	724.5	1.1	255.8	196.3
4	41605.3	255.4	209.2	256.4	199.1	225.7	740.3	1	255.7	214.4
5	45140.2	274.2	210.3	273.2	203.1	235	774.3	1.1	272.5	216.2
6	46430.7	277.8	214.8	274.7	194.8	237.8	790.8	1.1	273.2	220.6
7	46444.8	280.4	212.2	282.1	209.8	238.1	782.9	1.1	281.4	217.3
8	47931.7	282.8	218	288	207.4	241.9	816.4	1.1	290.8	228.1
9	50232.2	295.1	217.2	286.5	202	247.7	817.6	1.1	287.9	218.2
10	50737.1	297.5	218.6	294.2	205	248.4	826.1	1.1	294.4	228.9
11	50821.3	290.8	225	290.9	210	250.2	838.5	1.1	289.7	230.9
12	51466.6	294.8	224.4	293.8	197.4	250.8	837	1.1	293.4	233.2
13	52672.9	298.8	225.5	298.5	221	253.6	833.8	1.1	298.5	234.3
14	53191.9	293	232.9	296.2	211.1	255.2	844.5	1.1	292.3	241
15	54286.1	302.8	231.6	302.4	206.3	258.2	869.6	1.1	302.4	234.1
16	55338.1	291.4	243.8	293.8	240.7	260.9	861.6	1.1	299.9	250.3
17	58017.4	301.3	247.8	306.8	244	266.4	887.3	1.1	302.9	261.5
18	59335.9	297.9	255	296.2	234.6	270.6	886.7	1.1	296.3	256.1
19	63095.3	323.3	251.3	323.9	243.2	278	934.5	1.1	325.2	268.3

20	63768.6	339.4	243.6	337.3	236.5	277.5	951.2	1.1	338.4	260.5
21	63894.9	334.8	244	332	227.2	279.5	927.2	1.1	330.4	246.9
22	77739.9	341.7	291.3	342.3	274.3	310.1	1013.7	1.1	344.5	302
23	78441.3	395.7	259.4	380.3	237.9	305.8	1089	1.2	383.9	276.5
24	85749.6	389.6	286.1	395.8	257.6	322.8	1142.3	1.2	396.6	326
25	106861	454.9	304.7	473.9	282.1	359.2	1264.3	1.2	466.6	325

G.nepenthes 872C 3H 6 59-61 Hole 2

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	55450.4	312	227.8	314.4	210	260.3	942	1.3	315.2	258.3
2	56109.6	300.3	238.6	300.5	225	263	854.6	1	300.4	246.5
3	57764.9	319.8	231.1	322	212	265.1	902.2	1.1	316.7	225.4
4	58466.2	323.8	231.9	317.3	218.4	266.5	900	1.1	315.9	237.7
5	59083.5	315	239.7	312.9	233.7	269.3	890.1	1.1	311.1	247.3
6	61987.1	315.3	253.3	324.3	250.4	275.6	923.6	1.1	324.5	268.5
7	63193.5	322.1	251	321.5	240.9	278.2	915.4	1.1	319.3	259.3
8	64119.3	348.4	235.8	339.4	217	279	940.7	1.1	340.5	241.2
9	67584.1	350.8	247.6	347.4	230.7	286.3	972.1	1.1	348.2	257.9
10	69155.1	337.6	263	341.6	249.6	291.5	1010.9	1.2	344.7	279.9
11	70852.5	363.1	253.8	352.6	232.8	292	1012.9	1.2	354.2	271.1
12	71175.1	349.9	263	351.1	248	294.6	1024.2	1.2	352	294.4
13	72465.6	373.7	248.9	371.1	234.4	296.2	1007.2	1.1	371.2	258
14	74162.9	371	256.7	364.2	240.8	299.9	1018.7	1.1	363.7	269.6
15	79647.6	405.9	255.6	397.2	226.4	307.5	1098.5	1.2	400.7	276
16	80405.1	373.1	277	376.4	270.9	313.8	1062.5	1.1	374.5	292.3
17	80980.2	375.1	276.6	373.1	262.2	314.9	1046.6	1.1	374	283.7
18	82312.8	402.4	263.9	391	243.9	314.9	1093.3	1.2	391.6	275
19	85721.5	399.8	277.7	391.7	263.7	322.3	1109.7	1.1	393	296.1

20	88036	386.1	294	382.8	269.9	328.2	1109.7	1.1	385.4	300.5
21	92847.4	395.1	301.6	396.7	288.1	338.2	1129.8	1.1	397.3	313.7
22	94376.4	432.4	281.6	426.5	252.5	337.3	1171.4	1.2	427.8	290.9
23	94516.7	397.5	308	398.9	286.1	339.7	1164.6	1.1	402.6	334.5
24	101544	438	300.7	434.9	293.2	350.7	1231.9	1.2	439.5	315
25	112977	446.1	328.3	452.9	320.7	372.2	1281.2	1.2	453.7	351.7

G.nepenthes 872C 3H 6 59-61 Hole 3

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	39865.9	259.2	197.1	250.4	180.4	220.7	730	1.1	251.7	199.4
2	42461	261.5	207.8	262.3	203.8	227.9	742.4	1	262.9	214.6
3	45434.8	273.5	214.6	268	193.3	236.7	851.2	1.3	269.9	227.5
4	47033.9	284.4	211.8	288.1	206	239.5	809.9	1.1	289.8	228.9
5	48591	275.4	225.7	273.4	217.3	244.3	796.9	1	271.7	230.9
6	50456.6	281.4	229.2	287.8	220.4	249	817	1.1	289.3	233.9
7	51256.2	302.2	218.9	297.8	201	249.3	847	1.1	299.3	228.8
8	52476.5	291.5	231.5	293.3	204.5	253.4	846.5	1.1	291.2	237
9	52785.1	305.6	223.2	301.5	212	254.8	849.1	1.1	302	233.6
10	53262.1	295.1	231.2	294.1	221.1	255.2	839.7	1.1	295.6	240.1
11	57035.5	317.2	231.5	312.3	221.1	263.7	877.9	1.1	311.5	237.2
12	58901.1	311.3	242.9	313.3	229.6	268.9	890.5	1.1	316.8	254.7
13	61650.5	322.8	244.8	324.7	225.8	274.7	922.9	1.1	331.8	253.2
14	62422	323.2	248.9	323.9	228.1	276	928	1.1	323.1	269.1
15	67471.8	352.6	246.7	347.5	239.5	286.1	981.4	1.1	349.7	268.9
16	74191	366.1	261.9	361.5	243.4	300	1032	1.1	366.7	277.5
17	80377.1	385.3	269.6	395	261.3	312.7	1085.5	1.2	394.8	293
18	80601.5	361.4	286.1	363.4	266.3	315.1	1043.4	1.1	362.8	296.3
19	83617.4	408.3	263.7	403.4	249	318.2	1163.5	1.3	399.7	277.8

20	83855.9	372.1	290.6	379.2	290.1	321.1	1072.5	1.1	382.9	307.7
21	84220.6	387.6	279.7	390	251	320.3	1083.9	1.1	373.9	276.9
22	87236.5	395.2	284	392.5	276.5	326.8	1108.7	1.1	393.1	304.6
23	93057.8	396	303.2	399.5	296.5	337.6	1143.1	1.1	397.8	325.2
24	94250.2	418.6	290.8	414.9	256.3	338.8	1163.2	1.1	413.3	304
25	103031	430.6	307.8	425.2	274.7	354.4	1231.1	1.2	424.6	310.7

G.nepenthes 872C 3H 6 59-61 Hole 4

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	35685.7	238.3	191.7	237	182.6	208.7	680.7	1	236.7	198.4
2	40651.4	256	203.1	252.7	192.8	223.1	729	1	253	208.9
3	44523	279.7	203.7	292.7	199.8	232.3	818.4	1.2	288.4	207.2
4	45196.3	271.3	213.4	274.3	201.2	235.1	778	1.1	273.6	224.3
5	45504.9	262.3	222.3	261.9	211.2	236.9	773	1	264.7	225.3
6	46865.6	275.4	217.6	279.9	214.6	240.1	784	1	278.4	226.7
7	49951.6	292.7	219.6	290.4	206.6	246.5	826.5	1.1	288.8	232
8	50007.7	297.9	216.1	296	206	246.2	828.9	1.1	295.2	226.2
9	50274.2	297.5	217.6	287.2	200.3	246.8	824.1	1.1	291.6	218.9
10	53304.2	301.5	226.6	303.4	214.4	255	852.4	1.1	303.3	231.6
11	53879.3	312.6	220.5	310	214.5	255.9	855.5	1.1	309.7	230.3
12	53991.5	299.6	232.2	304.8	224.8	256.5	861.3	1.1	306.3	244.5
13	59335.9	326.6	233.3	315.8	216.7	268.6	899.1	1.1	313	232.2
14	61524.2	321.6	246	315.4	229.2	274.3	913.9	1.1	319.7	246.9
15	65255.5	348.4	242	340.8	228.5	280.8	959	1.1	341.7	255.8
16	70529.8	329.2	276	330.8	270.1	294.6	977.5	1.1	331.7	291.1
17	72690	366.9	253.6	362.1	235.7	297	995.7	1.1	362.7	265.3
18	72970.6	376.3	251.7	366.5	236.7	295.7	1068.3	1.2	368.2	260.2
19	76295.1	381.6	258.5	423.4	249	304.1	1171.1	1.4	426	274.8

20	79661.7	378.6	273.3	377.6	263	310.6	1075.2	1.2	377.5	296.8
21	79872.1	387.3	265.9	392.1	243.9	311.3	1075.3	1.2	393.2	284.3
22	90280.4	420.4	276.1	414.4	265.9	330.8	1135.9	1.1	417.6	287.6
23	115249	475	313.7	466.6	284.7	373.5	1299.5	1.2	467.7	325.9
24	147456	531.8	358.2	538.4	360.8	424.2	1489.7	1.2	536.2	378.1

T.truncat 871A 2H 4 124-126 Hole 1

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	88527	377.2	301	370.8	276.7	330	1097.7	1.1	377.8	300.9
2	88555	381.3	299	380.7	277.5	330	1099.2	1.1	381.4	306.1
3	89130.2	361.8	315.4	365.8	293	332.6	1087.8	1.1	358.9	320.4
4	89733.3	378.4	304	374.6	288.7	332.6	1101.9	1.1	380.5	306.6
5	91290.4	372.3	314.6	371.9	291.4	336.4	1104.2	1.1	368.4	321.1
6	93520.7	381.8	314.8	387.2	296	339.8	1128.4	1.1	378.1	319.8
7	93717.1	379.9	317.7	378.4	286.8	340.2	1140.9	1.1	378.7	321.2
8	96733	390.6	317.4	394.5	299.3	346.2	1139.2	1.1	390.4	326.7
9	97813.1	398.6	314.7	402.9	296.6	347.3	1162.3	1.1	394.6	318
10	98724.9	406.9	313.2	409.3	297.1	348.7	1194.4	1.1	412	314.9
11	102877	402.3	328.2	404	306.5	356.6	1181.8	1.1	400.7	328
12	106370	398.3	343.7	407.7	315.7	362.7	1237.9	1.1	402.5	368.1
13	110817	399.6	354.2	397	334.7	371.4	1202.5	1	391.7	354.2
14	111139	420.5	340.5	433.9	317.8	369.9	1260.9	1.1	434	361
15	111378	407.2	351.1	406.4	326.6	371.9	1229.1	1.1	396.6	360.1
16	113552	431.5	339.8	437.1	313.2	373.5	1269.8	1.1	434	354.6
17	113692	432.8	337.3	430.5	309.9	374.9	1268.8	1.1	436.4	347.8
18	116428	420.5	354.5	426.1	348	380.2	1246.9	1.1	434.2	362.5
19	117087	430.1	349.7	430.5	319.2	380	1269.4	1.1	422.1	357.1
20	119766	432.6	354.6	429.8	325.2	385	1276	1.1	425.5	357.9

21	121590	432.7	361.5	437.1	338.7	388	1298.9	1.1	438	368.8
22	126948	431.7	376.8	426	341.7	397.1	1314.6	1.1	419.5	372
23	132980	451.6	377.1	452.1	346.1	406.5	1348.6	1.1	449.4	377.6
24	133176	447.6	382.9	453.9	347.2	406.3	1364.7	1.1	445.5	389.5
25	148115	479.6	396.4	488.6	360.1	428.3	1444.5	1.1	463.4	410.7

T.truncat 871A 2H 4 124-126 Hole 2

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	64680.4	313.1	265.2	312.9	245.7	282.3	930.9	1.1	311.7	271.1
2	65480	323.3	260.9	323.2	243.6	283	948.1	1.1	325.6	266.8
3	65704.4	327.7	259.8	325.9	224	282.7	987	1.2	328	274.6
4	69940.7	329.5	273.4	331.3	255.6	292.6	1055.8	1.3	333.6	280.3
5	72633.9	336.9	277.5	335.4	258	298.8	1008.9	1.1	333.5	286.7
6	83280.7	354.3	303.1	357.8	270.1	320.5	1078.8	1.1	356.1	313.7
7	84501.1	344	314.3	343.9	279.8	323.5	1124.2	1.2	343	320.9
8	85188.5	374	294.8	379.9	258.6	322.6	1105.5	1.1	371.7	307.7
9	86212.5	361	305.6	357.1	295.4	326.8	1073.3	1.1	358.8	314.6
10	87755.5	384.4	294.3	377.6	274.3	327.9	1109.3	1.1	385.5	300.2
11	90266.4	376	308.5	380.6	287.8	333.5	1112.7	1.1	376.7	312.8
12	92973.7	382.7	314.9	388.8	287.8	338	1185.8	1.2	388.9	328.9
13	93366.4	375.8	320.5	376.9	288.2	339.5	1148.3	1.1	370	324.7
14	97546.6	412.3	305.4	425.9	297.8	346	1266.7	1.3	450.4	317.2
15	100030	401.5	321.6	396.7	286.7	350.6	1269.2	1.3	394.7	324.8
16	100380	388.7	331.4	391.3	297.1	352.5	1177.7	1.1	377.2	335.6
17	103999	398.5	334.8	402.9	311.8	358.8	1183.6	1.1	396	345.9
18	106412	403.6	339.4	407	308.5	362.7	1218.1	1.1	403.4	345.6
19	109666	421.1	337.3	416.5	314.9	374.1	1239.6	1.1	409.9	345.7
20	113454	432.4	338.9	426.1	311.8	373.4	1278.6	1.1	424.3	350

21	113566	420.7	348.5	418.2	321.7	374	1273.9	1.1	414.8	350.1
22	116470	417.9	359.4	426.5	312.5	379.5	1472.2	1.5	416.3	407.4
23	117227	424	354.6	424.6	326.7	381.1	1271.8	1.1	429.3	360.9
24	143599	462.9	397.9	470	371.9	422.4	1400.5	1.1	456.8	400.8
25	147667	481.9	393.4	475.7	347	427.8	1451.7	1.1	477.6	403.6

T.truncat 871A 2H 4 124-126 Hole 3

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	58438.2	291.8	256.8	306.2	243.1	268.8	911.1	1.1	294.6	256.7
2	63951	318.9	257.8	332.3	247.3	280.1	993.1	1.2	340	261.3
3	69870.5	328.8	273	330	247.3	292.8	1022.1	1.2	331.1	283.7
4	71904.5	328.6	280.4	324.7	263.8	298.3	971.3	1	321.8	278.2
5	76982.4	346.5	285.1	343.8	268.5	308.2	1014.8	1.1	346.7	285.6
6	79507.4	341.1	299.4	342.5	274.9	313.5	1030.7	1.1	340.2	303.4
7	79703.7	351.2	292.2	355.5	270.1	313.3	1053.1	1.1	347.8	304.3
8	85735.5	364.3	301.9	360.3	280.2	325.5	1083.5	1.1	359.8	300.9
9	88078.1	375.4	301.7	378.3	279.8	329.4	1097.9	1.1	375.7	310.8
10	88709.3	364.9	311.3	362.1	282.6	331.8	1155.8	1.2	363.9	312.7
11	93408.5	373.4	321.2	368.9	298.3	340.2	1137.6	1.1	370.1	325.2
12	94937.5	382.8	319.1	382.8	294.8	342.2	1137.1	1.1	376.7	325.5
13	95877.3	382.3	322.1	380.6	299.6	344.1	1143.3	1.1	379.2	331.2
14	98949.3	386.5	329.3	392.1	302	349.7	1168.6	1.1	386.7	327.2
15	100983	384.1	337.7	399.1	321.3	353.5	1263.8	1.3	391.7	355.6
16	104574	401.2	335.5	400.3	305.4	359.2	1216.1	1.1	396.2	340.2
17	110634	408.1	347.5	413.6	332.3	370.7	1253.1	1.1	406.4	361.4
18	112374	421.8	342.2	434.8	312.4	372	1397.5	1.4	434.3	372.7
19	117830	421.1	359.8	421.5	327	382.1	1277.5	1.1	419.9	364.1
20	122586	447.4	352.5	456.9	332.8	389.5	1415.5	1.3	456.2	360.2

21	124648	434.9	367.6	437.3	335.1	393.3	1329.8	1.1	433.8	367.1
22	125054	438.2	366.2	447.3	345.7	393.9	1320.9	1.1	441.8	380.3
23	129557	447.9	372.1	488.5	336.4	401.5	1551.6	1.5	484.7	369.5
24	130020	440.7	378	440.5	351	401.7	1340.9	1.1	435.7	380.2
25	153867	475.7	414.9	477.8	386.7	437.5	1469.9	1.1	466.2	434.5

T.truncat 871A 2H 4 124-126 Hole 4

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	74738	327.8	291.6	328.3	267.2	304.6	999.1	1.1	322	295.7
2	75790.1	344	283.5	349	268.5	305.6	1021.6	1.1	347.9	288.3
3	76968.4	342.8	288.1	345.6	272.8	307.8	1019.9	1.1	344.4	285.6
4	77810	348.7	286.4	351.2	263.3	309.6	1031.9	1.1	346.2	291.3
5	78820	363	279.3	363.3	264.9	310.7	1049.4	1.1	358.9	283.8
6	80938.2	346.9	299.7	344.9	271	316.3	1042.7	1.1	353	299.6
7	81176.6	375.1	278.2	373.7	249.8	315.2	1073	1.1	374.8	283.6
8	85244.6	368.5	297.8	360.8	274.7	323.7	1087	1.1	363.4	302.3
9	86422.9	368.6	301	367.1	288.8	326.4	1082	1.1	368.9	301.9
10	86717.5	360	309.7	360.2	277.7	327.4	1089.3	1.1	350.7	305.6
11	87460.9	374.9	301	377.2	283.8	327.2	1135.8	1.2	381.3	313.9
12	89158.2	369.8	308.8	364	289.8	332	1095.1	1.1	366.2	309.7
13	92552.9	356.8	331.4	363.6	316.9	339.4	1108.7	1.1	360.4	333.9
14	98668.8	391.9	323.3	392.3	296.5	349.4	1162.3	1.1	388.5	335.5
15	100801	405.4	320.1	407.7	295	353.5	1184.2	1.1	414.3	324.6
16	101362	398.2	327.2	408.5	310.9	354.2	1179.7	1.1	398.6	336.3
17	105458	400.9	338.3	408.3	313.3	361	1207.1	1.1	402.1	348
18	109246	420.3	335.2	429.1	300.8	367	1322.5	1.3	439.3	341.8
19	116624	406.6	366.4	409.3	348.3	381.5	1249.6	1.1	407.8	373.3
20	119359	420.7	363.5	432.7	336.9	384.8	1285.6	1.1	414.6	371.4

21	124087	434.2	367.8	442	345.9	391.7	1309.8	1.1	432.7	373.6
22	127130	454.4	361.2	460.7	335.1	396.4	1400.5	1.2	462.4	369.1
23	137244	456.8	386.9	468.3	347	412.4	1384.3	1.1	448.8	395.4
24	138268	462	384.9	477.4	357.5	413.8	1389.9	1.1	458.1	385.8
25	145001	457.2	405.3	453.2	379.8	425.4	1375.3	1	447	404.6

M.limbata 872C 5H 1 59-61 Hole 1

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	157935	511.3	395.5	511.2	362	441.9	1527.3	1.2	501.3	403.9
2	160628	516.8	398.4	522.3	339.8	445.3	1503.3	1.1	524.3	402
3	165636	524	403.6	521.7	377.1	453.7	1561.4	1.2	525.8	399.9
4	200269	543.9	470.6	546.1	439.1	500	1659.5	1.1	548	479.3
5	201784	564.3	457.6	578.1	434.5	502.1	1807.6	1.3	551.4	456.8
6	201897	541.2	477.7	548	448.9	501.8	1653.6	1.1	533.1	492.4
7	203888	559.5	469.6	589.9	426.1	504.3	1953.4	1.5	576.2	533.8
8	212964	583.4	468.5	584.7	425.9	514.8	1733.5	1.1	588.3	470.3
9	219613	584.2	481.2	584.4	454.1	523.1	1736.4	1.1	574.9	488.3
10	227328	580.3	501.3	606.7	479.2	532.6	1791.8	1.1	609	511.1
11	252241	647.8	498.5	648.2	473.1	559.5	1868.9	1.1	647	503.3
12	259816	658.6	505.4	663.4	461.3	568.2	1908.4	1.1	662.5	522.8
13	274194	640.3	550.2	658.6	523.8	584.6	2001.7	1.2	661.9	579.8
14	281698	656.5	552.2	677.3	469.1	592.9	2040.6	1.2	665.3	560
15	311633	706.1	566.4	719.1	482.2	622.9	2107.3	1.1	716.4	569.3
16	316977	698.3	582.9	697.1	519.5	628.7	2117.5	1.1	699.8	584.3
17	368332	778	611.1	786.6	518.9	676.1	2381.6	1.2	788.4	645.9
18	380999	756.5	645.2	762	592.1	690.1	2312.6	1.1	722.4	642.7
19	423123	829.1	655.3	842.7	611.9	726.6	2418.4	1.1	837	667.7
20	444739	801.5	709	800.4	662.4	747.1	2603.2	1.2	793.2	738.4

21	568391	934.4	778.3	953.8	719.1	844.2	2873.7	1.2	949	791.9
22	599377	985.3	779	982.6	715.6	864.8	3045.9	1.2	974.3	793.4
23	671169	1030.1	836.6	1028	743.8	916	3256.9	1.3	1034	880.1
24	732596	1080.8	868.2	1107.8	812.6	958.4	3416.3	1.3	1107.6	891.8
25	934913	1252.5	961.2	1250.7	867.1	1078.5	3816	1.2	1252.8	1018.9

M.limbata 872C 5H 1 59-61 Hole 2

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	174305	533.5	418.8	531.1	396.8	464.7	1559.8	1.1	515.8	427
2	214465	617	444.2	606.7	422.2	514.6	1708.6	1.1	600.8	440.1
3	222839	575.3	496.1	595.6	453.8	527.6	1838	1.2	576.5	489
4	262635	638	526.8	635.4	484.5	571.8	1905.1	1.1	630.1	524.6
5	354403	720.6	628.9	718.4	588.7	666.4	2184	1.1	704.4	635.7
6	384239	834.2	591.2	819.6	527.9	688.2	2356.3	1.1	827.5	606.2
7	394858	826.3	613.1	824	563	700	2340.3	1.1	826.1	620.9
8	408955	783.3	668.6	805.3	601.7	716.2	2468.6	1.2	761.2	680.9
9	422478	831.3	655.1	837.7	566.8	723.3	2510.5	1.2	837.5	670.3
10	437627	859.9	654.1	873.6	589.9	737.4	2508	1.1	876.3	683.6
11	448288	837.7	687.9	850.4	599	747.9	2601.2	1.2	849.1	707.3
12	448583	879.9	657.4	909.1	578.8	745.8	2742	1.3	881.5	707.3
13	453310	928.6	633.2	916.1	540.7	743.7	2694.2	1.3	918.4	657.5
14	475291	865.4	706.5	854.9	648	769.9	2653.1	1.2	843.9	741.7
15	476581	867.7	704.7	876.6	640.2	771.9	2677.4	1.2	863.2	767.8
16	481196	920.3	672.1	932.3	633.9	772.4	2654.4	1.2	921.7	699.3
17	483637	837.2	740	836.7	672.7	778.8	2605.6	1.1	814.2	744.4
18	498688	893.3	715.5	913.2	620.5	788.8	2861.7	1.3	886.6	721.1
19	518790	918.6	723.7	929.6	665	804.6	2772.9	1.2	915.8	729.6
20	530713	884.8	766.9	887.2	697.1	816.3	2763.3	1.1	869.8	774.2

21	539691	888.9	775.5	881.4	742.7	823.7	2681.2	1.1	879.7	785.6
22	561279	959.7	752	933.8	646.4	836.5	2823.7	1.1	934.1	753.6
23	566048	963.2	760.7	949.2	664.4	838.9	3163.7	1.4	960.1	832.6
24	629733	1019.6	796.6	1023	676	883.9	3139.2	1.2	1024.9	840.4
25	659723	1051.5	804.3	1067.5	740.4	906.5	3310.4	1.3	1063.8	820.7

M.limbata 872C 5H 1 59-61 Hole 3

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	256449	654.7	504.7	653.7	448.9	563.1	1981.9	1.2	657.6	515
2	298139	706.2	541.4	709.6	490.9	608.6	2037.9	1.1	708.4	540.9
3	339085	741.7	587.7	747.9	536.7	650.8	2209.7	1.1	729.5	597.6
4	366101	748.9	627.4	743.8	565.6	676.1	2270.9	1.1	726.7	631.8
5	391870	796.8	632.3	821.9	575.9	698.7	2352.6	1.1	810.4	641
6	456915	875	672	874.4	620.5	752.9	2528	1.1	878.7	698
7	463381	875.9	681.5	881.2	586.9	758	2673.7	1.2	879.5	699.9
8	486611	919.3	681.2	926.3	671.7	776.6	2644.2	1.1	918.7	719.6
9	487873	877	709.9	888.5	674.2	781.2	2617.4	1.1	888.5	724
10	494719	872.2	727.4	876.6	659.7	786	2645.7	1.1	848.9	746.1
11	511215	881.5	743.7	885.1	660	799.5	2664.7	1.1	871.3	744.2
12	519197	883.9	749.9	874.8	695.9	807.3	2669.3	1.1	876.3	754.9
13	546887	909.9	767.8	927.7	711.6	829.2	2735.8	1.1	919	773.1
14	557449	981.8	726.9	970.1	682.4	833.6	3098.4	1.4	975.4	740.2
15	566469	986.3	735.9	980.6	658.9	839.8	2877.6	1.2	976.9	736.4
16	585111	951.6	792	959.3	711.2	855.2	2965	1.2	952.9	813.6
17	600079	952.9	804.5	955.7	763	868	3044	1.2	939.7	812.7
18	611399	982.1	794.1	981.3	737.9	876	2866	1.1	981.7	780.4
19	612914	973.5	806.7	1011.3	767.4	876.6	3022.2	1.2	1013.7	809.7
20	622859	1008.7	794.8	1000.9	681.7	880.2	2990.4	1.1	995.5	796.3

21	627600	1035	780.4	1048.7	706.9	882.6	3002.4	1.1	1046.9	816.1
22	661561	1042.7	815.3	1045.5	734.2	908.5	3224.7	1.3	1044.1	828.2
23	662935	1069.8	796.9	1074.2	725.6	907.1	3092.4	1.1	1046.8	802.9
24	816872	1165.9	900.7	1172	815.4	1009.4	3424.7	1.1	1180	942.7
25	861886	1195.6	927.8	1213.6	867.6	1037.7	3552.8	1.2	1205.3	964.9

M.limbata 872C 5H 1 59-61 Hole 4

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	205011	578.4	453.7	587	437.3	505.2	1684.3	1.1	588.7	472.7
2	240977	577.1	533.3	605.3	517.7	550	1850.6	1.1	604.8	551.4
3	257950	670.3	492.4	673.9	470.2	565.6	1889.5	1.1	670.1	514.7
4	262018	663.2	508.2	663	462.4	569.8	2061.2	1.3	662.2	524.5
5	288881	699.7	531	700.2	470	597.9	2059.9	1.2	703.5	565.2
6	290129	755	492.1	757.3	469.7	596.5	2024.5	1.1	757.7	505.3
7	343615	736.3	602	740	540	653.6	2237.6	1.2	742.2	618.3
8	347263	754.8	593.1	826.7	543.4	658.3	2742.9	1.7	852.2	606.6
9	353014	795.2	566.2	795.4	541.9	661.9	2204.3	1.1	796.3	566.1
10	356549	754.8	604.6	759.4	571.2	667.9	2312.1	1.2	732.8	603.7
11	361108	817	566.3	830.8	550.6	667.3	2247.9	1.1	831.5	580.9
12	371151	757.8	628.8	763.5	584.6	680.2	2319.6	1.2	787.8	623.3
13	405855	830.5	627.2	848.3	611.4	709.2	2447.6	1.2	846.8	643.3
14	412518	798.7	662.9	810.2	617.2	718.3	2526.8	1.2	805.4	694.2
15	426293	795	684.1	806.2	661.1	732	2395.9	1.1	806	684.3
16	434583	843.6	661.7	831.8	591.2	735.4	2493.6	1.1	822	667.2
17	462862	866.6	683.9	866.4	624.6	760.3	2505	1.1	861.4	672.8
18	470662	894.3	677.6	894.4	589.9	763.9	2593.3	1.1	893	689.8
19	474267	881	689.5	899.9	635	768.9	2689.8	1.2	867.1	705.1
20	571898	1007.9	728.2	997.3	686.8	841.9	2867	1.1	1002.5	746.9

21	588015	959.7	781.7	967.7	717.8	859.5	2955.2	1.2	983.4	791.6
22	635105	1002	811.6	1027	799.2	892.4	3034.5	1.2	1027.3	847.6
23	664927	990	858.6	996	819	914.3	2986.4	1.1	1006.6	866.9
24	695325	1082.7	830.8	1071.7	706.7	928.6	3192.8	1.2	1082.3	843.3
25	770189	1063.7	925.4	1098.3	856.2	984.2	3544	1.3	1084.1	972.6

G.subquadratus 872C 5H 1 59-61 Hole 1

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	39206.6	250.8	204.7	246.2	173.3	221.4	734.5	1.1	240.7	197
2	43176.4	254.4	217	249.9	191	230.3	755.9	1.1	245.7	209.7
3	44803.6	264.7	219.2	260.2	195.3	234.9	788.1	1.1	254.1	221.5
4	47188.2	270.7	223.6	266.7	190.3	240.6	840.4	1.2	255.3	217.7
5	48338.5	271	229.4	268.1	214.5	243.3	808.9	1.1	266.3	232.9
6	48366.5	264.2	234.7	263.5	210.6	244.1	817.4	1.1	262.4	248
7	51284.2	281.9	235.3	277.5	214.9	251.4	844.8	1.1	278.4	237.4
8	51326.3	283.3	240.1	282.6	217.1	254	901.4	1.3	278.8	240.3
9	52504.6	286.1	236.5	306.9	214	253.6	922.6	1.3	302.1	246.7
10	53220	295.4	232.3	290.9	206.1	255.5	870.2	1.1	285.5	230.8
11	53528.6	300.5	229.9	293.8	198.3	256.6	865.6	1.1	290.9	223.9
12	53584.7	288.5	238.4	280.9	208	256.7	857.3	1.1	279.5	236.5
13	53725	293	234.6	283.6	199.4	256.6	845.8	1.1	284.5	223.8
14	53795.1	287.4	241.5	280.1	224.5	256.9	860.8	1.1	275.7	247.5
15	55716.9	297.4	241.9	291.9	223.9	262.2	920	1.2	288.3	246.9
16	57877.1	303.2	246.1	299	226.4	266.6	902.7	1.1	296.4	254.8
17	59490.2	311.7	251.3	312.3	228.6	272.8	927.8	1.2	309.8	257
18	61355.9	310.3	257.3	304.9	226.4	274.9	963.4	1.2	296.7	273.7
19	62828.8	311.6	259.1	326.2	222.1	278	998.6	1.3	307.6	259
20	68523.9	326.4	273.1	326.2	244.2	291.4	982.2	1.1	322	277.2

21	71441.6	338.8	277.7	333.9	251.9	297.8	1048.7	1.2	328.4	290.7
22	71595.9	340.4	271.3	335.2	237.4	296.9	1050.1	1.2	329.9	266.5
23	72648	334.9	281.8	332.4	254.8	299.7	1008.9	1.1	327.8	284.8
24	79703.7	362.2	285.8	367.4	248.6	313.1	1115.1	1.2	351.2	292.7
25	84010.2	369.1	294.5	366.5	254.7	320.7	1161.3	1.3	374.8	303.9

G.subquadratus 872C 5H 1 59-61 Hole 2

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	36527.4	238.2	198.2	236.2	181.2	213	707	1.1	234.3	197.7
2	39585.4	247.1	205.4	245.1	183.6	219.7	727.2	1.1	236.5	204.4
3	40048.3	252.1	204.2	249.9	183.6	220.8	744.9	1.1	240.1	207.6
4	40539.2	253	207.4	248.1	175.6	224.4	736.3	1.1	243.1	200
5	42418.9	262.3	210.1	255	184.9	227.9	788.5	1.2	251	214.5
6	44873.7	266.2	216	259.8	194.5	234.4	776	1.1	264.1	220.6
7	45743.4	261.5	224.8	258.7	212	236.8	786.3	1.1	257.3	230.4
8	46234.3	262.1	226.6	262.2	199.4	238.3	789.9	1.1	260.4	229.1
9	48829.4	275.5	228	268.5	215.6	245.1	807.2	1.1	268.6	230
10	53402.4	296.7	238.8	295.4	210.1	260.2	873.9	1.1	293.9	238.2
11	53486.5	292.1	236.5	285.8	210.8	257.7	852.7	1.1	286.4	228.6
12	57821	300.8	249.4	297.1	210.9	266.7	909.9	1.1	290.7	260.7
13	58887.1	314	247.8	332.5	213.5	271.7	998.6	1.3	316.8	253.9
14	59364	317.2	245.4	308.8	224	272.1	928.5	1.2	310.8	250.8
15	59448.2	311.2	252.5	304.9	221.5	273.8	935	1.2	303.9	254.5
16	63249.6	316.6	258.1	315.8	228.5	278.1	1068.9	1.4	303.6	285.7
17	64175.4	324.2	255.8	331.1	217.1	280.8	976.1	1.2	314.8	257.3
18	65830.6	321.9	263.1	316	221.5	285.2	945.9	1.1	303.4	250.7
19	68131.1	326.5	268.2	320	232.2	289.2	975.1	1.1	318.3	269.6
20	70529.8	328.1	276.6	358.5	246.9	295.4	1041.2	1.2	328.6	271.7

21	73335.3	347.8	277.9	337.6	240.8	305	1028.5	1.1	332.3	270.5
22	83771.7	366.9	294.3	357.5	250.9	321.9	1083.7	1.1	348.3	292.1
23	86731.5	372.1	299.6	374.5	247.6	326.3	1119.4	1.1	358.2	300.3
24	87503	380.3	296.7	368.6	243.5	328.1	1121.5	1.1	364.5	289.9
25	108909	415.1	339	406.2	297.4	368.2	1260.7	1.2	403.5	342.9

G.subquadratus 872C 5H 1 59-61 Hole 3

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	34367.2	226.3	194.5	222.5	180.7	204.8	667.9	1	222.6	196.1
2	40735.6	252.8	207.2	246.2	176	223.4	748	1.1	240.8	205.5
3	42503.1	261.1	209	260.2	193.1	227.8	755.5	1.1	255.1	211.8
4	43246.5	256.5	217.9	251.2	202.7	231	765	1.1	248.2	223.9
5	44466.9	274.8	208.2	266.5	176.7	232.5	802.2	1.2	270.2	213.4
6	44565.1	261.1	219.6	254.9	206.3	234.4	769.6	1.1	254.1	220
7	45392.7	264.4	219.6	257.2	199.9	235.9	776.9	1.1	253.7	216.7
8	47749.3	275.8	221.9	267.7	196	241.6	803.6	1.1	263.3	215.4
9	49502.7	277.7	229.4	281.8	203.5	246.3	846.9	1.2	265.7	227.8
10	50709.1	283.9	231.2	279.8	206.4	248.3	853.6	1.1	276	236.4
11	51354.4	291.9	228.5	285.8	202.3	251.7	851.5	1.1	281.2	225.1
12	51999.6	293.3	227.7	283.6	187.3	252	850.4	1.1	283.5	222.6
13	52476.5	281.1	241.2	278.4	222.1	253.6	852.8	1.1	273.6	247.2
14	52841.3	293.2	232.2	288	206	253.6	854.6	1.1	287.4	238.7
15	53542.6	288.1	237.8	284.7	209.8	256.3	849.1	1.1	277	227.7
16	57091.6	300.6	246	294.9	206.3	265.9	887.8	1.1	291.9	239.3
17	67303.5	314.9	275	314.1	251.9	287.7	981.5	1.1	314.3	279.9
18	70515.8	339.7	268.7	330.5	228.5	293.9	1037.9	1.2	328.8	272.3
19	76379.2	362.6	290.1	356.9	258.4	317.9	1101.5	1.3	355.8	294.3
20	76814.1	347	284.8	340.8	228.5	306.9	1101.4	1.3	338.5	290.2

21	80840	358.5	292.7	363.8	243.5	316.3	1170.6	1.3	352.1	289.5
22	83042.3	371.7	295.8	362.4	262.2	324	1109.2	1.2	358.6	299.9
23	83224.6	372.6	289.6	372.1	254.7	320.1	1135.2	1.2	366	297.3
24	85679.4	380.7	290.9	376	251.9	324.6	1126.6	1.2	374.5	296.1
25	103691	422	318	413.4	265.9	356.4	1226.1	1.2	410.7	322.3

G.subquadratus 872C 5H 1 59-61 Hole 4

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	39010.2	245.9	209	247.3	199.4	221.6	746.1	1.1	251.3	216.2
2	42937.9	255.7	215.2	252.9	191.9	229.7	757.7	1.1	245.6	210.5
3	45238.4	259.6	226	256.6	208.7	236.4	786.6	1.1	254.2	233.4
4	46108.1	267.7	225.4	269.2	213.1	239.1	801.4	1.1	267.7	234.9
5	46136.2	262.3	227.4	257.2	213.7	239.2	837.8	1.2	256.5	230.8
6	50232.2	283.1	227.5	277.5	203.5	248	823.4	1.1	277.9	227.3
7	50302.3	281.9	231.4	277.3	209.8	250.6	827.2	1.1	276.4	232.7
8	51915.4	281.1	236.2	275.5	199.4	252.6	832	1.1	272.2	234.4
9	52883.3	287	239.3	282.9	206.8	256.2	862	1.1	283.8	248.9
10	54342.2	300	233.6	290.7	184.1	257.2	881.2	1.1	286.4	230.2
11	54622.7	288	247.5	282.4	230	261.1	875.2	1.1	280.6	251.4
12	55969.4	300.8	239.7	293.1	213.1	261.6	894.1	1.1	292.9	243.7
13	59855	316.6	246.1	312.3	202.6	272	937.5	1.2	310.1	243.2
14	61047.3	311	251.4	305.4	217.2	274.1	909.9	1.1	300.6	244.2
15	61075.3	306.2	256.3	300.2	236.5	274.1	933.9	1.1	301.2	255.8
16	61131.5	314.3	251.1	304.9	221.1	273.2	929.1	1.1	299.8	253.8
17	61468.1	309.8	260.9	310.3	230	278	949.6	1.2	306.7	262.8
18	63011.1	321	253.6	320.1	221.5	279.9	943.2	1.1	324.8	244.8
19	64245.5	321.9	258.2	318.7	221.8	280.1	972.9	1.2	312.4	255.3
20	66195.3	325.9	261.5	318.4	232.8	284.7	965.6	1.1	312.1	265.5

21	72409.5	336.6	279.4	335.1	251.1	298.1	1020	1.1	334.3	293.6
22	73882.4	344.3	278.2	336.4	254.7	303.9	1006.4	1.1	330.9	276.8
23	74920.4	337.7	285.4	331.6	257.2	304.5	1007.2	1.1	327.1	285
24	76393.3	348.1	300.5	351.8	275.4	314	1100.7	1.3	354	309.5
25	80012.3	365	296.9	365.2	260.8	321.3	1119.6	1.2	360.2	306.6

G.ruber.seglei GLOW 3 BoxTop Hole 1

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	29738.1	206.5	188.6	207.4	174.9	192.8	635.8	1.1	201.5	192.5
2	42517.1	258.4	211.8	250.4	179.8	227.8	769.1	1.1	251	215.7
3	43022.1	255.8	217	256.4	199.8	230.7	759.9	1.1	257	217.8
4	47805.4	267.6	231.2	264.5	208	241.5	818.5	1.1	259.2	238.9
5	48015.8	278.8	226.3	272.7	191	245	826.8	1.1	273.9	225.8
6	55702.8	304	245.3	303.6	224.8	267	917.4	1.2	303.2	253.4
7	58171.7	320.8	237.6	313	183.6	268.6	931.6	1.2	314	243.5
8	58536.4	302.8	253.6	302.1	219.8	270.5	921.2	1.2	297.7	255
9	59406.1	303.9	257.6	302	234.6	273.1	928.7	1.2	293.5	260.4
10	62870.9	317.8	257.9	317.8	233.6	277.7	982.1	1.2	317.6	266.3
11	65662.3	327.8	269.3	327	230.2	288.6	1012.6	1.2	329.4	272.8
12	67584.1	343.3	262.4	338.8	236.5	293.4	1010.4	1.2	337.8	267.3
13	77473.4	340	298.9	356.1	283.1	313	1058.4	1.2	357.4	302.9
14	77950.3	352.3	288.3	348.2	237.2	311.2	1069.7	1.2	345.3	292.5
15	86436.9	352.5	318.4	360.5	293.2	328.4	1116.2	1.1	366.3	320.7
16	89494.9	371.8	319	371.4	297.5	337.7	1168.5	1.2	367.4	326.9
17	90392.6	374.2	320.1	373.7	292.1	335.8	1189.1	1.2	369.3	338.3
18	91136.1	396.2	299.8	395.3	240.4	335.6	1212.1	1.3	391.5	309.7
19	92230.2	397.7	312.4	393	258.7	342.8	1222.4	1.3	386.6	316.4
20	93703.1	389.3	315.5	389.7	259.3	341.8	1222.8	1.3	380.3	312.6

21	100408	421.2	329.5	421.5	271.3	361.9	1315.5	1.4	414.7	338.4
22	107829	400.5	356.8	412.1	333.7	370.5	1267.2	1.2	424.1	371.2
23	114856	442.2	338.6	430.1	299.6	377.7	1318.1	1.2	427.5	346.9
24	151033	513.1	385.6	490.8	313.6	434.3	1499	1.2	491.4	387.8
25	167501	535.6	416.6	536.7	355.8	458.7	1723.6	1.4	515.6	426.9

G.ruber.seglei GLOW 3 BoxTop Hole 2

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	43386.8	261.5	217.4	262.6	204.5	232.3	786.5	1.1	262	223.1
2	44593.1	274.3	220.2	268	194.5	240.7	813.2	1.2	265.6	223.2
3	48997.7	265.6	241.3	264.3	218.2	246.9	831.3	1.1	263.7	249.7
4	49502.7	281.7	226.8	278.9	199.4	246.5	831.4	1.1	277.5	232
5	51480.6	291.1	227.4	284.9	179	250.4	857.5	1.1	282.4	229.3
6	52658.9	288.7	234.4	289.9	201.7	254	854	1.1	283.3	235.2
7	53163.9	273.1	254.3	276.5	242.1	259.7	855.2	1.1	283.1	259.6
8	55506.5	311.3	241.8	306.5	198.3	267.9	924.4	1.2	298.4	233.9
9	55674.8	278.8	258.1	290.1	241	262.1	876	1.1	286	260.7
10	56474.4	301.3	249	299.3	223.9	266.7	929.3	1.2	300.5	258.1
11	56684.8	311.4	242.3	307.1	190.9	266.9	924	1.2	305.1	246.4
12	59714.7	313.3	246.6	304.7	198.3	270.8	926.5	1.1	306.4	245.7
13	60893	314.7	249.1	310.9	206.8	273.2	922.7	1.1	308.9	256.4
14	66518	322.9	268.3	318.7	232.8	288.6	958.9	1.1	314.9	261.6
15	69716.2	337.6	273.5	330.4	226.2	296.7	1020.2	1.2	323.4	266.1
16	69926.6	336.7	277.3	343.9	245.4	296.2	1062.8	1.3	330.2	290
17	73377.4	333.3	283.3	333.4	271.2	300.8	1009.5	1.1	332.9	295.5
18	79409.2	357.6	285.1	345.2	228.5	312.4	1070.9	1.1	346	285.8
19	86184.4	380	294.8	377	243.5	327.4	1117.1	1.2	369.1	290.8
20	97939.4	411	317.3	406.2	254.7	350.9	1245.7	1.3	392.5	317.2

21	105178	414.9	330.1	412.2	278.4	361	1245.1	1.2	409.1	338.1
22	107941	392.2	358.2	396.7	332	366.4	1274.1	1.2	395.3	369
23	127972	477.3	351	469.1	299.6	398.7	1428.3	1.3	466.7	354.4
24	130918	470	377	464.3	325.9	411.1	1430.3	1.2	451.9	392.2
25	144721	505.1	391.5	496.3	329.6	433.2	1666.6	1.5	489.2	397.5

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	41759.6	264.8	204.1	262.4	158.1	226.6	787.3	1.2	261.5	208.8
2	44537	269.9	214.8	264.8	171.8	235.3	791.9	1.1	263.6	215.5
3	46669.2	271.5	224.6	272.4	203.8	239.6	828.6	1.2	266.7	230.3
4	48647.1	282.2	224.1	280.8	202.7	245.1	829.3	1.1	280.1	228.1
5	58003.3	311.3	247.9	313.6	195.7	270.8	934.6	1.2	300.8	246.3
6	66279.5	325.6	262.7	320.3	229.6	284.7	972	1.1	317.7	267.2
7	68285.4	327.6	272.3	323.4	237	291.3	999.3	1.2	324.2	278.2
8	73251.1	344.1	279.9	346.1	259.5	303.3	1039.1	1.2	345.6	285.5
9	79465.3	348.6	297.2	346.3	254.7	310.5	1112.2	1.2	338.4	310.9
10	81302.9	351.5	298.5	352.8	272	318.1	1048.8	1.1	346.8	295.9
11	87587.2	358.9	317.4	358.1	301	331	1111.7	1.1	362.9	324
12	88891.7	372.4	312.9	374	289.9	333.5	1154.8	1.2	375.5	323.3
13	89719.3	396	302.5	390	244.5	337.5	1190.4	1.3	385.8	303.4
14	94123.9	374.3	323.1	377.4	280.9	340.9	1156.4	1.1	361.9	316.5
15	101460	422.7	314.9	415.5	251.2	354.3	1242.2	1.2	414.2	318.7
16	102386	399.7	330.4	400.5	273.4	355.4	1221.4	1.2	377.8	318.6
17	102582	403	333.4	403.1	289.6	355.5	1257.6	1.2	398.2	347.8
18	107773	429.6	332	418.7	279.1	368.2	1276.9	1.2	409.8	328.4
19	111883	420.6	360.9	429.2	323.3	379.4	1377.6	1.3	419.4	374.6
20	112402	451.5	333.8	448.9	262.3	377.8	1368.1	1.3	446	341.9

21	114141	447.6	339.8	436.8	289.6	379.7	1354	1.3	432.8	346.4
22	115347	424.5	367	443	331.1	382.7	1457.6	1.5	436	385.5
23	120804	443.1	358.5	439.5	310.9	388.6	1357.2	1.2	438.8	371.3
24	133401	458.9	384.1	463.9	358.4	406.3	1461.3	1.3	468.8	407.5
25	152071	503.3	399	504.2	344.5	434.8	1553.4	1.3	493.7	412.9

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	40384.9	233.8	228.6	241.8	210.9	226.5	755.8	1.1	242.9	227.2
2	45561	276.8	216	271.4	183.5	238.4	803.1	1.1	271.1	212.2
3	48057.9	280.1	225.2	277.2	211.1	244.4	831.7	1.1	277.8	233.5
4	51045.7	287.6	229.7	280.5	206.4	249.9	870.3	1.2	276.9	239.1
5	51129.9	284.1	237.1	284.6	217.9	253	858.4	1.1	281	245.2
6	53037.6	276.3	253.7	283.1	234.8	258.8	904.9	1.2	280.7	259
7	53262.1	282.5	247.5	286.7	229.7	257.4	885.1	1.2	286	257.4
8	54412.3	291	243.6	286.1	226.3	259.8	875	1.1	280.9	246
9	55239.9	284.8	249.7	285.7	227.4	261.2	870.5	1.1	272.9	248.5
10	59911.1	295.1	263.4	300.7	239.8	271.6	927.4	1.1	304	268.4
11	62576.3	305.3	267.1	309.4	237.3	279.8	964.5	1.2	298.6	265.7
12	67976.8	330.9	267.7	325.7	224.8	289.7	994.6	1.2	322.8	272.5
13	74892.3	349.9	283.7	347.4	260.8	308.5	1044.5	1.2	344.9	286
14	76225	341	297	341.2	275.3	310.5	1072.5	1.2	339	311.5
15	78371.1	364.4	282.7	354.1	229.2	314.4	1055.4	1.1	352.7	279.4
16	79226.8	367	287	359.6	250	315.4	1111.7	1.2	355.2	293.3
17	83168.5	368.8	303.3	362.4	267.4	327.2	1136.4	1.2	361	308.7
18	88036	365.9	317.3	377.7	289	334.7	1159	1.2	374.9	325.6
19	95147.9	390.1	320.1	395.7	302.1	343.6	1197.9	1.2	396.3	336.5
20	108376	440.7	335.2	439.7	280.9	371.6	1344.3	1.3	436.8	350.3

21	111392	421.7	339.1	422.8	296.8	370.6	1250	1.1	400.6	334.6
22	118728	428.8	367.4	433.1	340	388.1	1339.2	1.2	428.9	386
23	119500	459.6	338.2	459.9	286.2	381	1393.4	1.3	449.2	352.2
24	142505	492.9	378.2	476.6	316.6	420.5	1497.3	1.3	462.8	379
25	169311	525.3	436.1	530.9	384.6	466.9	1708.3	1.4	518.1	456.7

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	18095.4	156	149.2	155.8	136.3	148.3	479.5	1	151.4	149.9
2	18389.9	166.9	140.9	166.9	134.3	150.1	488.3	1	165.3	143
3	18474.1	155.9	152.1	158	140.2	150.5	485	1	155.9	149.7
4	20003.1	176.6	145.4	174.1	138.1	156.8	515.2	1.1	174	152.1
5	21209.4	181	150.3	177.5	140.4	161.2	534.7	1.1	175.1	155.6
6	21265.6	171.5	159.3	176.5	147.6	161.3	537.8	1.1	178.6	168.6
7	21672.4	180.3	154.4	183.6	143.9	162.6	542.1	1.1	182.8	163.8
8	22191.4	179.9	157.8	177	152.8	164.7	534.6	1	176.2	158
9	22275.5	181.6	158.4	180.1	144.6	164.5	550.6	1.1	178.8	163.9
10	22289.6	195	146.6	191	135	164.8	546.5	1.1	194	149
11	23846.6	194.3	157.4	188.5	149.2	171.7	558.9	1	188.8	161.8
12	24169.2	190.9	163.6	194.8	146.1	172	578.7	1.1	196.7	174
13	24365.6	184.2	169.1	184.1	162.6	173.5	556.1	1	185.2	171.8
14	25684.2	193.5	170.9	191.3	164.2	176.9	576.2	1	195.9	174.3
15	27255.3	198.1	176.6	193.8	165.5	181.8	600.8	1.1	193.9	181.4
16	27269.3	193.2	181.6	197.7	171	183	600.4	1.1	195.5	183
17	27886.5	191.9	186.7	200.2	170.4	184.8	604	1	200.6	192.2
18	29415.5	208.3	181.3	212	172.5	189.4	626.7	1.1	212.2	190.9
19	30299.2	211	184.2	216.1	176.1	192.5	634.4	1.1	216.3	190.7
20	30355.3	207.5	188.3	210.6	174.6	192.5	635	1.1	210.1	195.2

21	31870.3	220.4	186.5	221.1	170.8	197.2	662.6	1.1	220.2	194.6
22	32108.7	211.7	195.3	210.1	178.4	198.1	659.4	1.1	209.9	198.6
23	35124.6	220.2	205.2	223	187.6	207.3	689.9	1.1	222.2	218
24	38785.8	226.1	221	230.4	201.9	218.6	727.3	1.1	226	224.5
25	45154.2	261	222.3	260.8	206	235.6	791.9	1.1	259.8	231.3

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	17323.9	159.3	140.3	161.7	129.8	146.3	484.4	1.1	158.9	142.1
2	18544.2	172.7	139.2	172.9	131.1	150.8	502.7	1.1	173	144.6
3	18600.4	177.7	133.8	174.1	125.6	151.1	491.8	1	173.5	136.9
4	19161.4	172.1	142.1	171.2	134.3	153.4	495.3	1	171.2	144.7
5	20634.3	171.5	154.9	174.2	147.4	158.9	520.8	1	178.1	159.1
6	21700.4	179	156	179.8	143.1	163.1	536.8	1.1	182.6	163.5
7	21896.8	177.4	158.9	174.4	151	163.1	535.8	1	174.4	162.7
8	22542.1	173.4	166.9	179.2	144.1	165.6	546.2	1.1	174.3	168.5
9	22612.2	176.9	163.9	180.4	151.5	165.7	542	1	179.1	169.5
10	22640.2	179.6	161.9	181.7	154.4	165.8	546.4	1	182.6	170.8
11	22920.8	188.4	155.8	194.3	146.1	167.5	549.8	1	192.6	158.4
12	23327.6	182.4	164	184.5	156.4	169.3	550.8	1	184	169.5
13	24477.8	196.2	161.1	191.9	142.6	171.5	581	1.1	189.6	161.9
14	25347.5	199.7	162.6	199.9	153	176.1	578.8	1.1	195.2	168.4
15	26385.6	193.9	175.4	207.8	167.5	179.3	620.3	1.2	191.3	182
16	26750.3	200.9	171.1	203.5	164.2	180.5	593.1	1	204.4	181
17	27858.4	204.4	174.4	201.7	164.8	184.3	598.4	1	201.7	180.4
18	27942.6	201	179.2	199.5	167.2	184.8	630.7	1.1	196	183.6
19	29471.6	206.1	184.4	212.9	172.7	189.4	628.3	1.1	212.4	194.5
20	30144.9	201.6	193	202	180.2	192.6	635.6	1.1	206.4	189.7

21	31042.7	211.4	188.8	217.4	177.5	195.2	643	1.1	218	200.8
22	31589.7	218.4	186.1	220.3	177.6	196	658.7	1.1	220.6	193.3
23	38365	238.7	206	240.8	187.6	217.5	714.5	1.1	236.4	217
24	49965.6	272.6	235.4	274.7	223.4	247.8	824.7	1.1	275.3	246.6
25	59209.7	305.8	247.5	301.1	216.7	269.9	897	1.1	303	247.7

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	20185.4	167.3	155.3	171.2	141.6	156.8	514.2	1	168.6	161.3
2	20480	179.9	146.5	180	134	156.7	522.9	1.1	182	154.5
3	21111.3	172.2	158	171.9	145.4	160.1	530.8	1.1	171.5	162.1
4	21251.5	171.3	159.7	172.9	153.7	161.5	529.2	1	170.3	165.7
5	21896.8	179.2	157.2	180.8	149.2	163	542.8	1.1	181.4	164.9
6	22079.1	182	155.3	180.7	146.3	165	537.1	1	177.2	157
7	22808.6	176.9	165.6	181.2	153.6	166.6	547.4	1	183	173.3
8	23257.5	180.7	165.7	184.8	156.9	168.9	559.1	1.1	187.9	175.1
9	23271.5	179.1	167.1	180.7	152.1	169.1	556.2	1.1	177.4	174
10	23355.6	182.3	164.6	180.1	156.3	168.6	550.8	1	179.4	169.2
11	23902.7	191.9	160.7	192.6	149.5	169.7	576.9	1.1	194.1	165.2
12	24505.9	198	159.3	204.9	147.6	174.6	586.7	1.1	204.4	171.7
13	25165.2	191.6	168.2	198.3	157.5	175.4	582.2	1.1	198.9	176.1
14	25557.9	202.6	162.3	221.5	158.9	176.3	618.8	1.2	221.3	173.1
15	26147.1	196.6	172.9	199.4	152.5	179.2	610	1.1	199.9	176.4
16	26792.4	195.2	175.8	198.5	155.9	181	590.2	1	188.2	166.4
17	28686.1	201.1	183	202.7	172.5	187.7	611.3	1	205.1	193.3
18	29766.2	215.5	178.2	216.7	168.2	190	645.7	1.1	214	191.5
19	30341.3	215.4	181.1	211.9	157.3	192.3	645.9	1.1	212.4	178.1
20	30481.6	216.6	182.1	217.9	170.8	191.7	651.9	1.1	219.5	187.8

21	31337.2	219.6	183	217.4	167.2	195.5	656.9	1.1	220	189.5
22	32094.7	221.5	186.1	220.5	176.5	198.5	657.6	1.1	221.2	195.6
23	33623.7	233.3	184.7	225.5	168.2	203.1	670.5	1.1	225.5	187.9
24	35194.8	233.7	192.5	230	180	208	699.5	1.1	231.8	198
25	37972.2	237.3	205.7	240.9	196	215.5	717.3	1.1	239.5	216.8

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	16257.8	153.9	135.3	152.1	125.2	140.2	459.9	1	154.3	137.2
2	18824.8	162.3	149.1	164.7	137.5	151.2	502.7	1.1	161.4	153.3
3	19778.7	171.7	148.7	165.5	129.8	156.3	516.4	1.1	170.2	145.2
4	20213.5	171.5	156.3	172.9	138.6	161.4	531.2	1.1	171.9	153.4
5	20241.6	177	146.8	177	140.8	157.1	520.4	1.1	179	152
6	21237.5	179.1	152	177.7	142.4	161.5	543.3	1.1	175	154.7
7	22023	181.3	157.1	196.6	135.7	166.1	594.1	1.3	190.7	153.6
8	22471.9	186.8	155	187.3	142.4	165.1	555.7	1.1	187.2	161.3
9	22612.2	175.3	167.7	180.4	155.9	167.9	550.3	1.1	183.6	175.5
10	22752.5	183.3	159.2	182.6	149.8	167.1	545.6	1	180.8	164.5
11	22752.5	189.4	154.9	188.5	137.4	165.1	558.4	1.1	187.3	156.8
12	23103.1	183	163.1	179.3	142.6	167.1	563.2	1.1	187	166.8
13	23215.4	178.4	167.6	189.9	154.4	168.5	598.1	1.2	187.4	165.5
14	23285.5	178.8	167	180.1	149.5	168.9	560.6	1.1	178.2	173.9
15	24099.1	191.2	161.5	191	149.2	172	565.1	1.1	192.3	167.8
16	24309.5	188.2	166	191.7	142.4	172.6	572	1.1	190.9	173.1
17	24842.5	190.1	168.1	191	151.5	174	579.6	1.1	188.1	159.5
18	25053	191.1	168.2	191.9	159.3	174.9	570.6	1	191.9	174.4
19	25333.5	190.8	170.8	192	159.3	177	587.8	1.1	192.8	172.5
20	25838.5	198.8	166.5	198.5	158.9	178	583.1	1	198.7	173

21	26105	184.5	181.8	191.2	162.8	178.6	584.1	1	191.2	190.7
22	26245.3	199.1	169.5	206.3	153.7	179.3	604.6	1.1	201.1	179.5
23	26427.6	196.8	172	197.1	162.1	179.1	588.2	1	197.8	176.7
24	26441.7	197	175.5	203.1	165.9	181.8	598.7	1.1	203.2	180.9
25	31407.4	221.8	181.2	220.5	168.3	196.2	653.4	1.1	219.9	188.7

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	41282.7	245.1	215.7	240.9	189.9	224.8	773.2	1.2	245.1	219.4
2	46374.6	251.5	236.7	261.9	209.4	239.2	788.7	1.1	259	241.4
3	48703.2	267.8	234.4	273.4	203.7	244.4	826	1.1	268.6	244.2
4	51017.7	264.4	248	279.7	219.8	250.8	857.5	1.1	264.5	244.4
5	60556.3	307.3	253.1	305.2	223.4	272.8	910.3	1.1	301.9	255.2
6	60822.9	298.5	260.4	301.9	243.1	274.6	913.9	1.1	301.3	274
7	62702.5	327.7	245.8	322.2	221	276.7	954.7	1.2	322.7	254.7
8	63011.1	306.6	264.1	323.9	237.9	278.5	938.2	1.1	323.7	276
9	63319.7	329.8	246.1	326.2	230.8	278	945	1.1	326.5	253
10	64371.8	298.9	276.8	310	252.5	282.2	930.3	1.1	311.8	293.1
11	64498	306	272.1	310.3	260.9	283.1	943.7	1.1	310.6	287.4
12	64568.2	314	265.1	315	249.8	281.5	961.9	1.1	312.4	272
13	65550.1	310.6	271.4	308.2	236.9	284.3	947.4	1.1	311.8	277
14	68201.3	332.8	263.5	338.8	240	289.3	981.2	1.1	338.7	282.9
15	68369.6	313.1	283.4	326.9	244.6	290.5	992.9	1.1	310.9	280.4
16	71511.7	344	266.2	347.3	259.7	296.3	990.5	1.1	347.1	278.5
17	72255.2	320	288.5	322.1	280.5	299.3	975.6	1	322	297.4
18	72816.3	320.1	292.4	321.5	245.3	299.4	1017.4	1.1	329.5	290.2
19	72816.3	347.3	270.9	344.7	247.2	297.9	1018.9	1.1	345	286.4
20	73531.7	322.6	293.8	337.2	271.4	301.6	1043.2	1.2	335.1	309.1

21	80587.5	333	311.8	347.4	268.5	315.4	1096.5	1.2	331.8	330.7
22	90056	381.9	302.4	386.7	284.9	333	1155.6	1.2	383.6	313.3
23	90210.3	388.1	299.3	391	266.5	333.1	1168.6	1.2	389.4	318.2
24	92356.5	360	328.7	365.3	302	338.7	1135.9	1.1	368.4	335.9
25	101895	406.9	322.2	418.8	283.4	354.1	1228.2	1.2	418.8	344.5

N.continuosa.acosatensis 872C 4H 3 59-61 Hole 2

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	45126.2	273.4	213.2	266.7	180.7	235.8	797	1.1	263.8	219.4
2	50204.1	268.6	238.8	269.7	226.2	248.9	814.9	1.1	270.1	240
3	50428.5	269.2	239.8	278.4	229.6	249.6	821.8	1.1	278.9	245
4	52196	289.2	233.3	293.7	203.7	252.4	875.9	1.2	294.8	249.9
5	52308.2	283.5	237.3	285.1	223.9	253.4	848.1	1.1	284.8	243.6
6	53051.7	272.2	250.4	278.8	239.8	255.7	844.6	1.1	279.2	260.8
7	53739	286.2	241.6	286.5	211.4	256.8	858.8	1.1	284.4	250.2
8	54496.5	281.5	248.8	284.7	218.2	259.2	863.7	1.1	274.7	248.6
9	57680.7	283.7	260.1	288.1	239.3	267.2	892	1.1	286.8	264.7
10	58564.4	290.6	259	288.2	223.5	268.5	902.3	1.1	287.6	252.5
11	59883	307.3	253.2	310.9	210.9	270	933.2	1.2	303.1	263.2
12	59995.2	318.1	241.8	321.1	228.7	270.8	952.2	1.2	321.6	260.5
13	62520.2	317.4	252.3	316.4	239.6	277	930.7	1.1	316.6	260.6
14	62814.7	299.9	271.1	305.4	246.3	280	927.6	1.1	294.9	281.3
15	63361.8	311.6	261.5	320.5	249	279.2	937.4	1.1	321.3	277.1
16	68860.6	316.4	282	324.7	260.9	290.9	988.7	1.1	325.4	295.9
17	71946.6	324.6	284.4	328	263.6	298.5	984.6	1.1	324.9	294.4
18	71974.6	317.1	291.8	331.4	260.2	298.1	1004.9	1.1	324.6	295.4
19	72395.5	326.9	283.8	334.5	274.3	299.1	996.8	1.1	335.1	294.9
20	73601.8	342.1	280.1	337.1	243.4	299.2	1043.3	1.2	339.9	290.2

21	74485.6	339	284.6	348	260.2	304.2	1025.6	1.1	351.2	300.1
22	75355.2	333.9	292.5	342.5	243.4	304.5	1052.6	1.2	332.2	298.5
23	77108.7	337.9	292.9	342.4	274.7	308.4	1023.2	1.1	340.7	299.9
24	85693.5	384	286.5	384.2	251.9	323.6	1117.9	1.2	385.7	300.8
25	93198.1	364.6	330.9	368.1	279.5	338.7	1177.9	1.2	374.4	354.1

N.continuosa.acosatensis 872C 4H 3 59-61 Hole 3

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	35166.7	237.1	189.8	237.2	171.8	208.1	691.6	1.1	235.7	193.2
2	42923.9	254.8	216.9	260.8	204.4	229.4	757.7	1.1	260.8	226.7
3	43078.2	248.4	222.6	251.4	210.6	230	766.3	1.1	253.6	224.6
4	49713.1	277.1	232.2	279.2	212.5	246.4	857.7	1.2	280.8	244.1
5	50568.8	263	246.5	269.9	217.2	249.2	834.8	1.1	270.3	260.8
6	63235.6	318.3	254.9	315.1	235.8	278.7	939.2	1.1	311.6	265.1
7	65367.7	331	254.8	332.5	246.5	282.4	968.4	1.1	334	273.6
8	67135.2	314.3	275	318.9	241	287.9	971.1	1.1	314.1	287.4
9	70445.7	324	277.8	320.3	255.6	295.1	970.7	1.1	323.3	277.5

N.humerosa.dutertrei 872c 5H 2 59-61 Hole 1

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	43849.7	251.4	223.7	257.2	201.3	231.9	782.3	1.1	244.1	218.2
2	49600.9	269.9	237.1	272.7	199.4	246.2	873.6	1.2	271	257.7
3	52602.8	281.8	240.5	281.5	203.9	254.4	874	1.2	291.1	254.9
4	54720.9	276.3	255.5	283.6	235.7	258.9	928.1	1.3	279.5	279.5
5	56712.8	298.8	244.6	296	219.4	263.6	908	1.2	295.6	256.8
6	59125.5	297.8	254.1	293.2	225.8	270.1	889.1	1.1	294.2	249.1

7	61468.1	306.7	256.8	305.7	237.2	275.6	925.1	1.1	305	264.3
8	61734.6	298.6	267.3	320.1	246.2	275.7	986.8	1.3	323.2	301.1
9	61748.7	300.8	263.8	303.5	246.3	276.2	954.1	1.2	303.2	282.7
10	63698.5	324.6	252.3	329.6	226.5	279.3	975.1	1.2	328.4	273.5
11	63951	326.2	252	326.9	234.6	279.1	960.4	1.1	326.6	266.3
12	64918.9	300	278.2	317.5	241.7	283.2	1000.4	1.2	301.2	282.9
13	65017	308.8	271.4	312.3	242.8	282.7	1022.7	1.3	310.9	301.3
14	66644.2	319.4	272.2	323.6	236.9	285.7	1033.6	1.3	317.8	292.1
15	67990.9	327.8	269.8	342.5	259.8	288.2	1068.6	1.3	341.9	285.6
16	71988.7	326.8	283.9	333.7	263.1	297.4	1003.7	1.1	331.4	303.7
17	72128.9	318.9	289.6	323.8	263.8	298.7	995.2	1.1	316.8	285.7
18	73082.8	341.1	277.7	338.4	255.6	298.1	1043	1.2	335.9	293.9
19	73489.6	339.3	278	343.8	260.9	300.7	1014.9	1.1	345.1	295.6
20	77445.3	334.7	299	354.5	246.3	309.1	1132.8	1.3	346.4	321
21	87376.7	381.3	295.9	407	263	326.9	1342.9	1.6	399.7	321.6
22	89873.6	352.9	328.8	370.2	300.2	333.5	1150.1	1.2	370.1	349.7
23	92861.5	373	320.8	376	278.3	338.6	1161	1.2	382.5	338.1
24	93043.8	365	328.3	379.1	292.1	339.3	1158	1.1	361.6	335.1
25	100689	397.6	325.1	404.7	285.2	353	1215.6	1.2	400.2	340.1

N.humerosa.dutertrei 872c 5H 2 59-61 Hole 2

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	41998.1	245.8	219.4	265.9	204.9	227.4	795.7	1.2	265.6	219.4
2	42208.5	245.5	222	247.9	203.8	228.4	748.6	1.1	251.7	228.5
3	50260.2	280.2	230.9	278.3	210.9	247.8	836.9	1.1	276.5	234.9
4	51017.7	279.2	234.6	279.7	203.8	250.1	832.5	1.1	274	243.6
5	52420.4	287.7	235.7	285.7	202.7	252.7	866.1	1.1	283.7	239.7
6	54763	288.2	246	284	210	260	914	1.2	290.5	258.4

7	55001.5	278.8	253.6	289.1	209.4	260.1	882.1	1.1	283.9	270.4
8	56881.1	301.8	241.7	302.3	223	263.9	910.6	1.2	296.8	268.2
9	58859	302.1	251.4	308.5	210.6	268.3	942.8	1.2	306.2	263.6
10	60766.7	304.6	257.9	306.2	243.1	272.7	932.8	1.1	307.1	276.8
11	61510.2	314.9	252.3	315.4	225.8	274	946	1.2	315.6	272.2
12	62772.7	306.1	264.6	315.4	242.2	277.4	944.2	1.1	311.9	279.3
13	63922.9	309	267.2	312.3	233.1	280.6	1033.9	1.3	305.3	281
14	67205.3	320.7	269	327.2	248.7	287.6	972.5	1.1	326.3	281.8
15	68958.7	338.6	264	333.5	215.3	289.6	1026	1.2	341.1	279.2
16	68958.7	321.8	275.3	328	260.8	291.9	1001	1.2	327	294.9
17	69660.1	321.3	278.4	315.2	237.3	293.3	1001	1.1	320	290.6
18	75818.2	343.7	284.9	345.9	230	305.4	1069.6	1.2	344.4	303.2
19	76140.8	338.3	289.5	343.3	267.5	306.2	1039.4	1.1	343.5	317.4
20	77753.9	348.7	289.2	351.2	239.8	308.6	1074.1	1.2	346.2	292.4
21	78974.3	348.6	292.2	355.5	245.2	311.9	1101.3	1.2	348.9	302.2
22	79984.3	352.2	294.1	355.5	271	313.2	1076.7	1.2	352.8	312
23	80054.4	361.5	286.7	390.4	234.6	313	1146.3	1.3	389.1	306
24	86128.3	353.1	315	367.7	282.6	326.1	1119.4	1.2	367.5	327.3
25	86927.9	371.3	300.5	377.2	277.4	327.3	1106.4	1.1	374.6	322.2

N.humerosa.dutertrei 872c 5H 2 59-61 Hole 3

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	32249	207.5	199.5	211.9	184.1	198.3	657	1.1	212.4	194.9
2	44410.8	257.4	221.2	268.1	196.1	233.4	772.9	1.1	252.3	225.1
3	48689.1	272.6	230.1	274.7	201.3	244.3	823.7	1.1	277.3	230.8
4	54496.5	291.3	241.5	294.5	230.4	258	903.8	1.2	294	250.7
5	55759	289.8	246.2	291.7	225.8	261.8	890	1.1	290	244.8
6	55871.2	296	242.3	304.7	212.8	262.1	940.6	1.3	299.5	240.6

7	56586.6	275	264.6	286.7	237.9	264.1	876.3	1.1	266.3	263
8	57175.7	302.4	242.4	307.2	225.1	264.8	890.5	1.1	308.6	253
9	60303.8	296.4	261.8	302.5	236.5	272	910.8	1.1	300.1	274.3
10	62856.8	327.1	246.5	326.2	232.1	276.9	989	1.2	326.8	255.2
11	63039.2	318	254.1	316.5	226.3	278.1	933.3	1.1	316.5	264.8
12	63375.8	319.4	255.5	323.9	242.2	278.7	951.5	1.1	323.7	271.4
13	65423.8	301.8	280.6	307.3	261.8	283.4	966.4	1.1	311	297.7
14	65816.6	307.9	274.4	310.3	256	284.9	961.8	1.1	311.9	275.7
15	66546	311.7	275.9	324.1	254.5	286.4	1001	1.2	322.1	294.4
16	68173.2	315.9	278.1	315.4	234	289.7	991.9	1.1	325.5	279.4
17	70123	324.2	281.1	322.1	255.6	293.3	1012.9	1.2	319.8	302
18	71357.4	334.4	273	336.5	244.9	296.9	1001.2	1.1	335.5	283
19	72044.8	336	276.8	331.6	244.6	297	1037.6	1.2	328.6	287.2
20	74078.8	337.4	285	335.7	259.3	301	1041.5	1.2	329.8	294.9
21	78399.2	348.8	289.8	354.5	254.2	310.4	1107.1	1.2	353.1	311.8
22	78693.8	353.5	285.9	357.8	250.4	311.4	1073.2	1.2	357.4	303.3
23	81429.1	358.4	292.6	358.2	244.9	316.2	1089.6	1.2	352.1	311.9
24	90462.8	383.1	304.1	384.6	261.9	333	1154.1	1.2	380.8	322.3
25	99356.1	387.5	329.8	400.8	299.3	350.4	1190.7	1.1	401.1	346.6

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	42573.2	245.7	222.6	250.4	191.3	228.6	765.2	1.1	240.9	216.1
2	45547	266.4	223.1	271.3	184.4	235.6	926.2	1.5	271.3	259.3
3	47076	248.5	244.4	256.4	223.5	240.6	804.8	1.1	250	248.6
4	51915.4	277.9	240.1	287.2	207.7	252.8	898.9	1.2	287.8	264.8
5	55646.7	300.1	237.3	295.2	214	261.6	884.4	1.1	293.8	248.7
6	59742.7	297.3	259.8	303.5	239.3	270.5	984.3	1.3	303.7	277.8

7	60612.4	301.4	259	313.2	229.6	273.1	954.7	1.2	318.2	272.7
8	62295.7	317.5	252	327	223.9	276.4	961.4	1.2	325.9	270.7
9	62323.8	306.4	262.8	313.8	244.2	276.9	1035.5	1.4	309.8	295.3
10	63866.8	302.6	271.6	312.8	255.1	280.2	966.7	1.2	313.5	284.1
11	65760.5	304	277.4	309.2	250.9	284.9	963.4	1.1	309.5	298.3
12	67836.6	331.3	265.7	335.7	227.5	287.2	1036	1.3	329.9	288.5
13	67990.9	310.1	281.4	316.5	261.9	289.9	965.2	1.1	320.8	295.9
14	68495.8	336.2	262.1	338	246.9	289.4	1003.7	1.2	337.5	281.8
15	69071	308.9	287.2	318.4	241	292.6	976.7	1.1	302.6	279.4
16	69099	328.5	272.3	335	242.2	291.9	1146.5	1.5	328.9	285.7
17	73475.6	331	287.3	351.8	268.5	300.6	1178.1	1.5	348.5	337.1
18	74555.7	329.1	292.3	335.4	252.3	302.9	1052	1.2	333.4	311.8
19	76477.4	336.3	292.5	345.4	268	307.1	1077.8	1.2	343.7	306
20	77192.8	348	285.5	349.3	267.7	307.7	1060.5	1.2	348.6	296.6
21	77866.2	352.4	283.7	350.3	253.5	309.4	1083.5	1.2	346.8	298.1
22	80741.8	341.4	302.7	345.3	285.8	316.1	1057.9	1.1	344.9	316.6
23	82859.9	346.1	306.3	351.1	276.7	320.5	1071.5	1.1	354.5	320.4
24	95905.4	391.7	315.5	409.1	300.7	343.7	1198.4	1.2	409.1	344.5
25	98556.6	401.4	322.5	426.4	284.7	346.9	1645.2	2.2	418	384.3

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	30748.1	211.8	186.7	210	180.7	194.9	634.7	1	211	187.8
2	32782.1	211.3	200.8	217.2	191.3	201.9	657.3	1	216.1	200.8
3	33848.1	227.3	201.5	230.4	187.3	209.8	722.5	1.2	229.1	203.5
4	35531.4	244.8	193.4	240.2	175.4	211.8	717.5	1.2	237.2	191.9
5	35601.6	239.1	194.8	244.5	168.6	211.4	710.9	1.1	245.9	190.9
6	35629.6	227.1	207.2	232.2	197	213.7	705.3	1.1	227.2	210.4

7	36822	236.7	203.1	234.8	183.7	213.7	716.9	1.1	230.4	207.1
8	36990.3	233.4	203.7	231.6	191.9	212.8	714.5	1.1	228.1	206.6
9	37383.1	245.5	197.4	239.3	165.5	215	714.1	1.1	236.1	190.7
10	38715.7	235.2	216.6	236.5	209.2	223.1	730	1.1	238.8	218.2
11	39080.4	242.6	208.6	238.6	195.5	220.7	722.3	1.1	236.1	209.9
12	39094.4	248.7	202.6	241.5	182.3	219	728.8	1.1	240.9	200.6
13	39136.5	246.6	205.3	240.2	189.9	220.1	729.1	1.1	239.8	209.2
14	39445.1	241.3	215.2	241.7	197.7	222.7	759.5	1.2	239.7	225.3
15	41254.6	253.6	208.3	249.5	180.8	225.1	742	1.1	250.1	202.8
16	44354.7	263.9	221.2	259.8	189.6	236.5	779.8	1.1	254.9	210.7
17	45687.3	262.3	223.1	260	203.9	237	775.8	1	258.9	221.4
18	45981.9	258.1	233.4	262.8	195.7	240.6	800	1.1	253.7	233.3
19	46276.4	268.8	224.3	260.9	202	240.7	786.5	1.1	260	220.7
20	46360.6	262.8	225.6	257.3	208.5	238.7	782.6	1.1	253.6	223.5
21	46444.8	275.2	221.6	268.1	206.3	240.9	828.5	1.2	268.3	229.6
22	51971.6	300.1	227.2	294.2	202.2	254.8	867	1.2	296.2	231.6
23	52757.1	282.9	240.7	278.8	229.2	255.9	841.5	1.1	277.3	240.9
24	57007.4	301.5	242.5	296.3	224.5	263.7	886	1.1	298.1	244.6
25	64946.9	317.9	269.8	313.6	246.4	285.3	983.3	1.2	306.6	278.5

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	26511.8	202.9	171.2	199.5	160	182	605.3	1.1	199	174.7
2	31084.7	215	188.1	210.6	176.7	196.9	637.2	1	209.3	190.6
3	32403.3	224.3	186.1	221.2	169.4	199.4	658.3	1.1	219.4	187.3
4	33315.1	226	193.8	222.3	176.1	204.9	670.9	1.1	220.5	190.2
5	33567.6	222.2	195.6	219.8	185.4	204.6	669.1	1.1	220	199.4
6	34142.7	212.5	206	214.9	189.9	204.6	671.2	1	215.3	213.7

7	34521.5	230.6	198.5	229.6	183.6	209.5	691.6	1.1	221.6	201.6
8	35713.8	240.4	197.7	236.5	176.1	213.5	706.9	1.1	235.6	197.4
9	37060.4	235.5	202.5	235.8	169	213.3	708.4	1.1	225.4	202.8
10	37116.5	235.3	203.8	235.1	192.6	214.6	702.7	1.1	236.5	201.6
11	37256.8	224.7	215.5	226.4	201.9	216.1	711.1	1.1	228.7	213.9
12	37326.9	243.1	201.2	240.2	184.4	215.9	723.7	1.1	235.1	204.5
13	37663.6	237.9	204.7	232.7	186.6	215.9	704.1	1	230.9	204.4
14	38028.3	247.3	203	241.8	190.3	219.4	726.1	1.1	242.5	207.2
15	38112.5	246	198.9	239.7	174.9	216.3	714.9	1.1	237	193.5
16	38771.8	232.2	216.2	230.2	204.8	220.3	715.4	1.1	229.1	219.4
17	39417	246.9	210.3	249.3	198.5	223	744	1.1	251.5	216.9
18	39599.4	245.7	207.7	243.7	199.5	221.8	727.5	1.1	246.7	211.4
19	40006.2	253.6	205.4	244.9	184.5	222.9	745.6	1.1	247.5	200.6
20	41128.4	239.1	223.5	238.4	207.8	227	741.9	1.1	232.3	226.2
21	42026.1	256.5	215.1	253.3	199.8	229.1	763	1.1	246.8	217.7
22	43583.2	259.3	215	254.7	202.3	230.9	756.2	1	252.9	214.7
23	43849.7	261.1	215.2	255.3	184.1	231.9	764.2	1.1	252	206.5
24	45673.3	271.9	226.9	271.4	205.7	242.9	813.9	1.2	266.8	232.8
25	50119.9	274.8	234.7	274	227	248.5	821.6	1.1	274.3	239.5

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	36541.4	236.4	204.7	238.4	187.9	215.4	715.3	1.1	233.9	208.9
2	38449.1	247.6	199.5	243.9	169	216.8	723.5	1.1	240.1	194.2
3	39655.5	242.1	215	243	202.7	224	740.8	1.1	245.5	220
4	40932	248.1	218.4	248.3	208	229.4	756.2	1.1	247.4	220.3
5	42404.9	252.5	219.9	251.8	210	231.2	759.3	1.1	251.1	223.5
6	44480.9	265.3	222.4	267	206.3	238	797.8	1.1	265.1	221.1

7	44635.2	258.4	223	258.5	211.5	233.5	782.3	1.1	262.8	233.2
8	44649.3	261	224.1	257	207.4	235.4	795.5	1.1	253	226.5
9	45336.6	268.6	215.9	263.5	187.3	235.5	777.2	1.1	265.1	214.5
10	45757.4	277.1	215.7	275.4	172.9	238.2	817.4	1.2	270.6	212.8
11	47104	267.6	233.8	272	218.4	244.4	821.4	1.1	272.3	239.9
12	47595	275.1	225.5	268.5	202.7	244.2	810.1	1.1	266.5	224.3
13	49320.4	291.8	224.8	292.5	199.8	249.9	845.6	1.2	291.1	227.1
14	50568.8	274.3	237.9	274.3	224.7	248.6	834.6	1.1	275.2	246.5
15	50947.6	282.8	234.5	279.8	209.4	251.4	838.5	1.1	272.6	237.8
16	52392.4	282.4	237.6	277.4	221.1	253.2	838.5	1.1	276.8	241.7
17	54524.5	298.6	237	293	214.7	260.4	862	1.1	290	235.2
18	54664.8	300.7	238.2	296.3	203.1	261.5	875.5	1.1	292.4	234.9
19	58255.8	310.4	241	305.4	223.3	267.1	896.7	1.1	303	246.9
20	58831	306.7	248.9	307.9	231.5	270.2	904	1.1	303.8	248.8
21	62113.4	313.2	263.5	318.4	238.6	281.4	969	1.2	316	263.9
22	66742.4	327.2	267.9	327	245.1	289.3	972.4	1.1	327.6	275.9
23	68748.3	345	264.6	347	233.3	294.5	1019.3	1.2	339.2	272.6
24	79801.9	365.1	287.7	368.3	269.7	317.2	1076.5	1.2	365.6	296.6
25	82607.4	370.1	287.6	367.3	255.7	318.7	1085.5	1.1	362.2	281.6

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	32852.2	216	196.7	218.4	187.9	201.7	662.2	1.1	219.7	200.5
2	35110.6	234.6	198.1	233.7	186.3	211	706	1.1	229.1	201.3
3	38954.1	238.4	211.7	242.1	200.1	219.5	724.1	1.1	242.7	217.2
4	39262.7	243.5	206	241.1	179.3	219.2	715.5	1	239.5	204.4
5	41016.1	251.5	208.6	248.6	194.8	224.4	734.5	1	247.2	206
6	43092.2	260.9	211.2	256.2	187.3	230	755.7	1.1	257.1	210.5

7	43990	263.5	214.6	260	180	232.5	774.1	1.1	255.5	212.4
8	44326.6	261.3	219.2	256.9	191.6	234	778.7	1.1	257.5	221.2
9	46052	251.5	235.4	254.3	220.6	238	779.7	1.1	257.7	241.6
10	46094.1	263.4	223.6	259.8	195.7	238	773.3	1	256.8	221.7
11	46136.2	270.7	217.9	265.3	200.2	237.7	780	1	265.3	217.1
12	47833.5	274.8	224.8	268.5	191	243.7	803.1	1.1	265.2	220.8
13	47903.6	262.5	242.8	270.1	229.5	248.1	833.9	1.2	264	247.6
14	48941.6	280.1	223.9	272.2	209.9	244.8	830.4	1.1	269.7	227
15	49039.8	271.5	232.7	271.8	221.2	245.4	818.4	1.1	268.5	238.8
16	49657	283.9	223.5	274.3	194.8	246.5	812.4	1.1	274.3	221
17	51564.8	284	232.8	282	195.5	251.6	838.9	1.1	279.8	234.7
18	53781.1	292.6	236.8	287.2	222.8	257.4	867.5	1.1	291.1	244
19	58480.3	302.7	247.5	294.2	217.4	267.7	894.5	1.1	293.9	241.4
20	59195.7	306	249.4	302	232.3	269.7	899.2	1.1	297.3	253.9
21	60247.7	317.1	246.9	315.4	226.3	273.7	920.7	1.1	316	251.7
22	80840	364.3	285.9	357.1	225.8	314.6	1086.8	1.2	352	284.8
23	93099.9	388.7	311.9	390.4	275.5	339.2	1164.9	1.2	382.7	312.2
24	93394.5	389	310.2	381.4	273.6	340.1	1152.1	1.1	380.7	313.5
25	121295	427.7	363.4	424.6	338	387.8	1292.5	1.1	420.8	369.5

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	38757.7	236.5	209.2	231.7	194.8	217.9	706.3	1	230.8	209.9
2	39024.3	247.9	204.4	241	175.6	220.2	721.7	1.1	235.9	193.3
3	39052.3	252.7	201.9	246.2	181.2	220.8	728.1	1.1	244.1	202
4	39641.5	244.7	207	240.7	184.5	220.6	717.5	1	237.9	202.6
5	41324.8	249.5	214.1	247.3	198.1	226.6	739.8	1.1	240.6	213.7
6	41380.9	251.6	210.8	245.5	177	224.8	744.5	1.1	239.3	200.8

7	41913.9	251.6	213	244.9	191.7	227	750	1.1	243.2	210.6
8	42348.8	262	213.8	259.8	184.9	232.5	766.1	1.1	257.9	207.6
9	43064.2	267.8	213.1	271	183.6	232.9	789.7	1.2	268.2	210.4
10	43681.4	256.3	219.4	256.4	188.2	231.9	786.9	1.1	250.9	213.8
11	46094.1	262.9	224	259.4	209.7	238.5	779.2	1	258.3	222
12	46248.4	263.5	225.5	261.5	194.8	239	785.5	1.1	254.5	218.8
13	47623.1	269.6	225.8	277.5	205.7	242.3	808.2	1.1	257.4	220.7
14	48071.9	264.8	232.5	260.8	210.9	243.2	796.6	1.1	254.9	230
15	50681	282.1	229.8	277.7	203.5	249.8	819.6	1.1	273.2	219.7
16	51340.3	283.6	232.5	273.7	214.3	250.9	844.2	1.1	272.6	231.2
17	51845.3	287.2	231.9	278.4	206.8	252	834.9	1.1	273.3	229.6
18	53374.3	292.7	237.6	285.8	209.7	258.4	865.9	1.1	278.6	235.7
19	58171.7	298.8	248.9	291.4	221.8	267.5	880.7	1.1	288.4	243.5
20	61215.6	309.9	261.5	310.6	236	279.8	939.9	1.1	300.4	257.2
21	63165.4	318.7	255.1	312.8	236	278.3	938	1.1	307.7	255.1
22	64287.6	322.2	255.2	311.8	232.8	280.7	926.4	1.1	307.3	251.4
23	73096.8	345	271.5	333.4	233.3	300	1007.1	1.1	329.4	266
24	77880.2	345	289.9	338.7	251	310.3	1034.9	1.1	329.9	281.3
25	83168.5	375.4	287.5	370	249	320.9	1093.5	1.1	365	281.1

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	34367.2	224.8	196.1	221.9	186.3	205.1	677.8	1.1	221.6	199.3
2	39206.6	244.7	205.1	239.3	183.6	219.5	723.3	1.1	235.3	203.9
3	39501.2	246.6	204.8	243.5	191.7	219.9	720.4	1	243.9	205.2
4	41927.9	253	211.8	247.3	187.9	226.8	744.2	1.1	240.6	208.7
5	42208.5	256.7	210.3	248.4	176	227.7	750.5	1.1	248.1	204.1
6	42881.8	253.8	219.3	251.1	198.5	230.7	759.2	1.1	249.1	218.8

7	43358.7	259.2	214.2	254.7	190.9	230.5	764.2	1.1	249.7	213.5
8	44480.9	253.7	223.6	250.7	210	234.3	757.1	1	250.1	223.5
9	46290.5	264.8	224.8	257.7	198.2	239.3	780.8	1	254.9	217.9
10	46837.5	277.2	222.5	271.4	182.9	242	824.6	1.2	269	223.4
11	48394.6	278.6	226.5	273.7	194.8	246	815	1.1	272.3	221.3
12	48955.7	282.3	222.5	274.8	198.5	244.7	816.3	1.1	272.3	217
13	52729	286.1	241	281.5	214.3	257.3	857.6	1.1	277.9	239
14	55057.6	291.8	241.5	283.6	222.8	260.3	868.8	1.1	280.5	240
15	55562.6	293.3	242.4	285.8	225.5	261.6	859.5	1.1	286.1	244.4
16	55688.8	297.6	239.8	288.6	210	261.9	873	1.1	285.2	232.7
17	55997.4	294.1	246	290.9	221.8	264.1	871.9	1.1	290.1	244
18	57302	296.5	249.2	290.7	229.9	266.4	884	1.1	285.7	248.2
19	58396.1	308.1	247	297.7	221.1	269	912.3	1.1	293.2	251
20	59055.4	310.9	244.4	301	218.2	269.2	903.1	1.1	301.9	246.3
21	61271.7	312.3	257	307.4	235.1	277.7	927.5	1.1	303.1	259.2
22	62997.1	309.6	261.8	305.2	232.2	278.8	916	1.1	294.5	257.1
23	64526.1	317.6	262.3	313.7	229.2	282.2	951	1.1	307.2	259.3
24	64666.4	313.2	272.4	316.6	251.8	286.5	957.1	1.1	312.7	278.7
25	66433.8	324.5	266.1	320.7	232.2	287.4	967.9	1.1	307	264.6
26	69463.7	326.2	272.6	317	243.9	292.8	966.2	1.1	315.2	271.6
27	75902.3	346.4	284.8	339.4	239.7	307.6	1039.4	1.1	330.1	281
28	78651.7	349.7	289.4	342.9	251	312.7	1041	1.1	336	285.4
29	80012.3	358.5	288.7	353	248.3	315	1067	1.1	347.8	284.8
30	91585	375.9	312	368.4	290.1	336.8	1107	1.1	368.8	312

G.subquadratus 871A 7H 5 124-126 Hole 3

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	36471.3	238.4	196.4	232.7	169.6	211.4	692.8	1	234.4	194.4

2	39459.1	250.5	204.4	244.9	175.6	221.1	731.6	1.1	240.8	196.6
3	40090.3	250.9	207.2	244.5	180.4	223.3	737.8	1.1	244.4	210.4
4	44915.8	272	222	267.6	181.5	240.8	807.6	1.2	263.4	215.9
5	45645.2	262.9	224.6	258.5	203.8	238	812.6	1.2	252.8	225.2
6	46276.4	272.3	217.4	263.6	188.2	237.9	784	1.1	262.7	208.2
7	49320.4	277.1	231.7	271.3	193.1	248.5	821.5	1.1	266.6	226.2
8	49699.1	285.6	229.9	282	203.8	250.2	841.6	1.1	279.1	234.3
9	50372.4	289	223.9	275.5	180.4	247.7	829.6	1.1	275.9	218.8
10	52308.2	287.2	234.4	279.7	207.2	253.6	847.9	1.1	276.2	236.4
11	52574.7	281.9	239.3	277.5	223.3	254.3	843.5	1.1	278.1	244.7
12	54300.1	299.9	233.5	289.3	201.3	258.4	864.7	1.1	285.7	226.4
13	55015.5	284.7	249.8	284.9	222.1	260.6	872.1	1.1	276.3	248.2
14	56853.1	297.5	247.1	293.6	223.9	266.5	882.1	1.1	288.5	246.4
15	57105.6	301.8	243.6	293.2	196	265.3	882.3	1.1	290.3	234.8
16	58802.9	307.5	250.5	302.4	205.7	272.1	905.2	1.1	296.6	242.5
17	60626.5	304.9	254.1	301.2	232.2	273.4	893.8	1	301.8	253.9
18	61341.9	306.9	258.3	303.3	221.8	275.9	911.5	1.1	300.9	250.8
19	62478.1	323.8	248.4	315.4	209.7	277	934.2	1.1	307.1	239.7
20	67878.6	323.5	268.8	315.1	244.6	289.2	958.8	1.1	311	261.9
21	68271.4	320	273.9	321	240.4	290.9	967.1	1.1	318.1	273.7
22	69407.6	330.7	271.9	327	221	292.6	1003.2	1.2	311.3	262.4
23	69519.8	324.7	277	320	258	294.2	988.1	1.1	317.4	282.9
24	76168.8	347.6	284.2	340.5	255.3	307.5	1034.9	1.1	334.3	285.2
25	148663	481.4	398.2	470.9	349.7	429.9	1461.4	1.1	463.3	406.8

G.subquadratus 871A 7H 5 124-126 Hole 4

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	31702	218.2	186	213.6	172.7	196.6	642.5	1	215	186.1

2	33357.2	224.2	195.2	223	180.7	204.6	673	1.1	219	194.6
3	34788	229.7	194.4	224.8	176.3	206	672.7	1	225	194.6
4	35166.7	229.9	195.7	227.4	180	207.5	679	1	221.2	191.6
5	35882.1	242.6	192.5	237.2	171.2	210.8	707.1	1.1	232.2	191.6
6	36457.2	232.8	201.1	229.6	183.5	211.4	694.4	1.1	224.2	200.4
7	37284.9	244.4	195.6	237	174.9	213.3	706	1.1	239.6	192.5
8	37495.3	243.2	197.5	238.1	180.4	214.3	706.4	1.1	235.7	199
9	38477.2	240.6	204.2	234.8	184.8	217.3	704.9	1	233.1	201.2
10	40188.5	256.5	203.2	251.1	187.3	223.1	741.1	1.1	251.2	202.6
11	41745.6	257.6	209.9	251.2	190.3	227.6	756.1	1.1	247.2	209.7
12	43919.8	257.6	218.4	254.3	194.3	232.3	763.8	1.1	250.3	212.9
13	45084.1	268.7	214.9	263.7	181.2	234.7	785.3	1.1	257.2	209.6
14	46543	267.7	222.1	260.8	198.5	239	775.9	1	259.4	214.5
15	47861.5	277.8	222.1	271.4	179.8	241.8	817.4	1.1	261.2	217.7
16	48324.4	274.1	226.2	267.1	206	243.9	802.6	1.1	262.2	222.1
17	49615	278.3	228.8	270.5	191	245.9	828.7	1.1	267.7	224
18	50260.2	279.9	230.4	274.8	210.9	249.1	822.2	1.1	269.3	229.2
19	51677	284	239.8	282.5	218.4	254.7	858.6	1.1	273.3	242.5
20	53725	288.2	240.9	288.5	218.1	257.1	873.8	1.1	284.5	240.9
21	56909.2	297.7	245.2	291.8	214.7	264.1	881.3	1.1	282	240.4
22	57498.4	293.3	253.2	289.8	228.5	266.9	893.4	1.1	286.1	255.1
23	58269.9	305.1	244.6	296.1	221.8	267.5	885.4	1.1	295.3	245.9
24	66475.9	322.5	266.5	320.7	242.9	287.3	963.5	1.1	320.1	271.1
25	71371.5	327.3	279.3	320.5	252.7	297.1	972.8	1.1	313.8	273.2

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	36541.4	233.5	200.2	235.7	178.1	211.7	692	1	227	199.1

2	40609.4	250.7	207.6	245.1	181.5	222.8	736.8	1.1	240	205.2
3	50681	269.6	240.3	268.2	223.9	249.8	821.3	1.1	270.6	237.5
4	52364.3	285.5	234.5	282	222.8	253.6	827.3	1	284.1	236.7
5	56993.4	299.9	243.2	293	210.9	264.5	881.7	1.1	289.5	246.1
6	57568.5	298.8	247.1	290.9	222.1	265.6	877.4	1.1	290.9	247
7	58802.9	304.8	246.8	297.5	220.8	268.9	879.3	1	292.3	241.1
8	61580.3	319.5	254.8	311.6	214	278.9	947.7	1.2	303.7	247.3
9	63361.8	311.2	262.8	306.5	228.5	280.1	933.6	1.1	296	255.1
10	64890.8	324.3	256.9	315.4	231	282.3	944.2	1.1	312.1	259.9
11	66882.7	318.8	268.9	311.8	239.3	287.3	951.5	1.1	306.4	268.8
12	67191.3	316.4	271.7	312.8	239.7	288.1	945.7	1.1	310.1	265.2
13	67303.5	336.8	256.7	328	219.2	286.6	958.5	1.1	326.3	256.8
14	69099	322.9	274.2	319.2	239.7	291.6	967.2	1.1	312.1	267.3
15	71062.9	324.2	280.7	322.7	244.9	296.3	992.2	1.1	318.6	282.1
16	71357.4	338.7	271.4	329.9	229.6	296.6	1007.1	1.1	327.9	258.2
17	81092.5	351.2	304.2	351.2	279.5	320.2	1068.6	1.1	347.5	310
18	81513.3	347.8	299.5	342.3	265.9	317.5	1037.1	1	339.2	282.9
19	82579.4	351.5	301	351.1	274.3	319.4	1064.7	1.1	344.3	310.6
20	83000.2	369.1	297	366	266.9	324.2	1091.2	1.1	365.4	302.5
21	84936	364.3	300.9	359.4	274.7	324.7	1078.2	1.1	352.6	305.3
22	94797.2	384.2	323.5	382	285.1	345.5	1175.1	1.2	378.5	321.7
23	96817.2	375.7	330	374.5	287.2	346.6	1147.2	1.1	367.5	326.2
24	107043	418.9	330.4	413.6	284.7	363.8	1238	1.1	414.3	334.4
25	153446	484.8	409.1	486.1	367	435.2	1498.9	1.2	476.8	424.3

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	31112.8	215.7	185.9	210	168.9	195.3	646.2	1.1	204.8	188

2	40174.5	247.2	207.6	243.4	190.9	222	722.7	1	240.6	205.4
3	42110.3	251.6	214.4	248.3	188.6	227.2	758	1.1	245.3	208
4	43036.1	256.6	214.6	250.4	191	230.1	757.6	1.1	244.7	210.8
5	47258.3	258	235.3	255.6	220	240.7	793.4	1.1	257.3	242.7
6	50596.9	277.4	233.7	276.3	203.9	249.6	825.1	1.1	265.5	224.9
7	56895.2	296.7	245.4	286.8	213.7	264.4	870.3	1.1	287.4	241.7
8	58873	305.5	248.2	300.5	202.3	268.9	901.3	1.1	291.5	240.6
9	59742.7	307.6	251.8	301.5	221	272.3	916.2	1.1	292.7	247.7
10	70642	326.8	277.9	320.6	263	295.1	979.4	1.1	317	285.8
11	70880.5	341.8	277.7	337.4	247.6	301.2	1023.1	1.2	328.7	279.4
12	76407.3	333.4	293.6	329.3	276.9	307.3	1003	1	329.3	299.9
13	80278.9	357.2	288.1	346.2	247.2	314.7	1044.1	1.1	339.6	276.8
14	82888	369.5	290.2	361.5	248.2	320.4	1077.8	1.1	359.3	281.2
15	84529.2	357.2	303.9	359.4	267.4	323	1100	1.1	338.8	299.8
16	90140.1	374.4	310.1	368.7	288.8	333.4	1115.6	1.1	366.8	311.2
17	92959.6	379.4	314.1	375.7	266	339.2	1139	1.1	367.1	314.7
18	93745.2	391.3	307	379	259.8	340.2	1126.8	1.1	377.4	296.6
19	103284	399.9	331.4	397.8	293.1	357.1	1187.2	1.1	383.2	323
20	103845	400.6	335.8	394.8	280.9	360.2	1194.1	1.1	386.8	329.4
21	109919	422.1	334.1	415.9	290.1	368.5	1234.7	1.1	411.9	327.6
22	115039	437	341.9	434	312.9	377.2	1283.4	1.1	425.3	350.2
23	123722	442.7	358.4	429.2	316.6	390.9	1299.5	1.1	424.4	352.8
24	125279	448	363	447.8	331.3	393.8	1348.6	1.2	441.1	371.8
25	193606	565.6	440.7	559.6	355.8	488.9	1671.6	1.1	536.4	418

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	38968.1	249	200.6	242.1	176.2	217.9	721.9	1.1	238.8	200.8

2	39431.1	251.2	200.9	248.2	187.3	219.9	719.4	1	249.4	200.3
3	41956	245.6	219	242.6	203.5	226.9	738.6	1	241.4	221.8
4	47538.9	267.8	227.4	259.8	209.4	241.8	790.6	1	255.3	225.2
5	49264.3	279.8	227.8	271.8	206	246.7	822.8	1.1	271.3	231.9
6	52546.7	284.8	235.9	277.2	199.1	253.9	847.2	1.1	274.3	229.7
7	53528.6	284.9	241.8	278.8	227.5	255.9	848.2	1.1	277.4	251.1
8	62912.9	308.9	260.8	305.2	243.4	278.5	917	1.1	303.1	261
9	62997.1	303.4	266	302.7	229.9	278.9	912.5	1.1	296.2	261.5
10	65129.3	311.6	268.4	307.3	230.2	283.3	938	1.1	300.1	270.1
11	70473.7	323.4	283.5	323.1	258.3	297.2	994.4	1.1	318.2	288.2
12	70684.1	317.8	287.1	318.4	271.3	295.5	987.8	1.1	318.7	293.1
13	71133	331.1	279.8	326.3	248.6	295.2	1025.3	1.2	317.9	289.6
14	73167	332.7	281.5	326.2	244.6	300.4	986.5	1.1	320.9	274
15	84473.1	362	300	355.2	266.9	322.7	1090	1.1	346.8	296
16	91879.5	365.9	324.3	362.4	296.1	336.3	1130.9	1.1	365	333.9
17	93380.5	390.1	307.9	380.3	259.3	338.9	1141.4	1.1	378.2	301.5
18	93913.5	378.4	320.1	376	290.1	341.4	1135.8	1.1	372.3	318.7
19	96971.5	387.7	322.9	385	282.5	347.9	1162	1.1	379.4	318.9
20	104687	403.4	334.9	397.3	297.4	359.8	1204.5	1.1	386.6	334.9
21	116343	434.6	345.4	427	303.5	381.2	1266.1	1.1	426.5	336.2
22	116357	428.4	348.3	420.8	293	379.3	1259.6	1.1	411.4	334.9
23	119808	443.1	346.5	440.9	298.2	385.2	1279.9	1.1	438.1	346
24	126682	438.2	371.3	443.6	329.7	396.7	1320	1.1	417.7	362.4
25	177783	534.4	433.9	535.6	381.9	472.3	1613.7	1.2	531.6	438.7

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	41591.3	255.7	208.7	249.5	188.6	226	744.3	1.1	244	210

2	43456.9	272.9	211.3	267.1	187.3	234.1	780.7	1.1	263.1	209.5
3	45462.8	259.6	224.7	260.2	202.3	236.1	773.8	1	256.3	223
4	46402.7	276.5	214.8	268	186.3	238.1	782.9	1.1	267.6	207.2
5	49390.5	262.4	242.3	263.1	229.2	246.2	809.2	1.1	258.4	247.3
6	52743.1	287	236.5	279.5	198.5	255	839.3	1.1	274.5	226.7
7	56993.4	295.6	248.1	290.9	214	265.3	880.1	1.1	291.6	245.1
8	72072.8	340.2	273.2	336.4	244.6	297.7	997.2	1.1	333.7	278.1
9	72353.4	322.5	290	322	271.2	298	1009.8	1.1	317.6	301.8
10	76786	340.5	288.2	339.4	263.9	308.2	1006.3	1	339.5	293.3
11	78104.6	352.2	286.3	341.6	239.7	311.5	1040.8	1.1	340.2	275.1
12	84557.2	370.7	294.8	364.2	255.4	324	1086.1	1.1	362.1	289.5
13	86016.1	364.4	304.2	356.9	267.2	325.5	1100.6	1.1	350.3	311.9
14	89186.3	373.7	308.1	370.2	289.1	330.8	1115.5	1.1	371.1	317.7
15	99580.6	393.3	325	386.7	293.7	350.9	1157.6	1.1	374.5	320.8
16	100577	392.2	331.5	391.7	304.7	353.2	1190.7	1.1	388.3	340.4
17	107043	406.5	346.5	412.5	313.6	368.1	1236.6	1.1	400.7	353.4
18	112430	411.7	352.2	407.4	301.1	374.4	1239.9	1.1	405.9	351.6
19	122123	441.7	358.2	432.7	319.2	387.7	1320.2	1.1	422.2	371.9
20	123217	446.9	354.3	443.1	319.4	390	1310.3	1.1	443.2	358.4
21	124886	434.8	368.1	427.1	314.6	393.5	1308	1.1	424.1	358.3
22	154905	494.9	403.3	494.8	352.1	437.5	1486.1	1.1	488.7	404.1
23	156069	491.9	408.4	483	345.9	441.2	1487.3	1.1	480	407.8
24	159632	512.9	401.5	503.2	328.2	443.4	1519.7	1.2	505.3	396.7
25	166337	516.6	415.1	509.1	345.9	453.4	1552.8	1.2	498.8	406.8

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	78399.2	345	293.2	355.8	264.9	311	1050.9	1.1	349.5	300

2	80377.1	346.3	297.6	356.3	273.4	315.3	1048.6	1.1	358.5	324.2
3	80517.3	364.2	285.1	372.8	277.9	314.6	1057.3	1.1	378.3	302.5
4	81176.6	374.6	283.9	408.7	267.1	315.6	1333	1.7	382.8	296.4
5	85314.7	366	298.9	361.3	279.1	324.5	1079.8	1.1	354.3	298.7
6	86871.8	351.7	319	358.5	302	328.7	1096.6	1.1	360	323.2
7	87531	359.3	312.3	364.5	298.2	329.7	1076.8	1.1	364.1	317.5
8	87797.6	360.4	312.8	375.2	292.1	329.9	1125.1	1.1	357.4	312.5
9	88078.1	394	287.7	379.8	259.1	328.3	1105.6	1.1	377.9	294.3
10	88709.3	364.1	313.5	365.3	304.2	331.3	1091.4	1.1	365	323.2
11	96578.7	393.3	316.6	387.4	301.5	344.5	1145.7	1.1	379.4	329
12	102975	418	320	430.2	301.9	354.4	1588.1	1.9	419.4	337.1
13	108614	432.7	325	453.2	312.3	364.2	1281.4	1.2	454.6	345.4
14	109821	416.4	338.9	426.9	323.6	369	1236	1.1	427	355.9
15	110508	423.2	337.5	413.8	323.3	368.2	1281.8	1.2	417.5	355.3
16	113636	429.9	340.3	427.2	325.2	373.6	1250.4	1.1	426.9	358.6
17	114997	446.4	334.5	455	315.8	374.7	1423.4	1.4	473	359.2
18	115572	428.4	350	445.7	337.6	378.6	1577.6	1.7	451.6	395.7
19	117606	430	351.9	434.9	317.2	381.4	1358.5	1.2	435.2	384.4
20	117830	423.9	357.9	437.1	343	382.4	1293.5	1.1	437.1	374.6
21	127958	459.3	358.9	455.6	347.4	397.3	1328.4	1.1	457.1	371
22	128197	445.1	370.5	462.9	348.4	398.4	1340.3	1.1	464	400.5
23	135224	483.2	363.4	484.8	343	407.4	1408.4	1.2	488.5	380.2
24	140204	490	371.1	498.1	341.2	414.5	1461.5	1.2	497.7	405.2
25	156812	495	411.6	498	395.8	439.7	1577.3	1.3	504.1	431

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	61496.2	314.6	250.9	309.2	240.2	274.6	905.7	1.1	308.4	257.5

2	66980.9	327.2	263.6	322.2	239.7	286.1	959.6	1.1	321.6	272.5
3	67920.7	324.1	268.7	330	262.3	289.7	947.1	1.1	334.8	277.3
4	69085	331	267.5	335.4	253.9	291.7	981.1	1.1	336.8	281
5	73293.2	348.1	270.7	343.3	258.9	299.6	1005.1	1.1	340.3	282.5
6	84332.8	358.4	303.5	365.6	299.9	322.3	1067.5	1.1	368.5	313.9
7	85104.3	360	304	367.1	296.7	324.3	1073.4	1.1	365.6	318.9
8	85567.2	359.7	304.9	367.9	285.7	325.3	1072.4	1.1	366.8	315.8
9	88597.1	393.2	290.5	385.6	275	329.4	1119	1.1	389.2	299.5
10	93352.4	399.2	301.4	397.3	293.2	338.2	1139.2	1.1	400.1	317.8
11	95835.3	398	308.2	402.7	287.2	343.9	1159.5	1.1	395.6	308.9
12	97658.8	398.6	314.7	394.5	304.2	346.8	1146.5	1.1	393.1	321.9
13	97911.3	404.6	313.3	401.3	299.6	346	1170	1.1	405.7	323.1
14	98458.4	411.9	308.3	406.2	278.4	347.3	1182.6	1.1	405.3	320.5
15	98724.9	399.6	318.4	401	308.5	348.7	1166.8	1.1	400.7	329.6
16	99229.9	408.4	314.4	405.5	293.2	348.7	1194	1.1	406.8	326
17	99650.7	401.4	318.7	401.5	306.9	350.4	1158.8	1.1	399	323.5
18	107562	418	332.7	439.7	316.4	364	1268.9	1.2	443	356.5
19	117816	440.2	348	427.8	323.9	379.5	1332.1	1.2	430.2	368.7
20	127579	455	363.2	447.7	338.8	396.2	1355.4	1.1	443.9	385.5
21	128168	457.4	361.6	461.9	347	397.7	1353.8	1.1	462.8	392.1
22	129361	463.1	363.1	452.9	329.6	398.4	1449.1	1.3	450	394.5
23	129599	456.9	367.1	451.9	350.1	399.4	1371.9	1.2	449.6	383.6
24	129866	465.6	358.9	456.3	340.8	399.6	1347.6	1.1	457.3	370.3
25	172748	527.2	426	531.8	394.2	460.5	1598.1	1.2	536	453.7

S.disjuncta.seminulina 872C 6H CC Hole 3

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	59364	310.8	244.4	305.7	229.6	269.6	885.3	1.1	305.9	247.5

2	68832.5	340.4	260.4	334.5	238.2	290.1	1003.5	1.2	326.3	258.9
3	72409.5	341.3	271.4	334.5	250.9	298.5	980.7	1.1	331.7	269.5
4	73124.9	328.3	286.7	336.3	263.6	300.1	1018.7	1.1	337.6	291.8
5	74485.6	355	269.1	349.9	244.6	301.6	1005.4	1.1	350.3	273.3
6	80489.3	360.1	286.7	350.4	265.1	314.8	1046.4	1.1	349.1	292.8
7	80671.6	334.2	312.5	338.8	294.9	317.7	1040.2	1.1	341.7	310
8	81723.7	365.2	286.6	356	265.9	317.2	1050.9	1.1	359.7	286
9	82607.4	381.7	278.5	379	243.5	317.5	1097.2	1.2	374.4	284.9
10	83715.6	377.6	286.4	372.1	260.8	320.3	1187.4	1.3	361	292
11	87811.6	364.8	309.3	368.7	297.8	329.3	1102.9	1.1	375.1	322.2
12	92609	395.7	299.8	404.3	289.8	337.8	1128.9	1.1	405.7	314.4
13	93254.2	376.2	320	380.3	315.8	339.2	1124.5	1.1	388	329.6
14	95077.8	400.9	307.7	391.7	285.7	340.1	1171.6	1.1	389.4	323.2
15	96550.7	374.8	330.9	378.3	290.7	346.2	1177.7	1.1	362.4	337.5
16	97364.3	398.2	313.2	408.7	297	346.9	1165.9	1.1	410	328.2
17	104771	414.2	325.4	415.1	319	359.4	1195.1	1.1	417.8	337.2
18	113650	430.4	341.6	433.9	320.7	373.5	1373.8	1.3	444.4	368.2
19	115768	431	345	460	335.2	378.7	1277.4	1.1	462.4	362.1
20	115824	446.2	334.4	442	307.1	377.3	1324.8	1.2	442	355.4
21	116470	436.5	344.7	436.4	322.7	377.8	1294.9	1.1	435.4	357.2
22	116792	445.3	338	445.7	329.3	378.9	1292.3	1.1	448	349.3
23	118223	421.8	359.1	428.3	333.4	383	1262.3	1.1	429.1	361.7
24	124928	443.6	364.7	458.4	346.4	392.3	1342.9	1.1	446.6	377.6
25	141172	485.6	376.9	477.1	338.1	415.8	1447.9	1.2	467.5	401.5

S.disjuncta.seminulina 872C 6H CC Hole 4

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	63698.5	317.8	258.6	359.1	253.3	279.5	1095	1.5	358.5	277.1

2	63894.9	309.3	265.4	313.6	254.7	280.6	948.4	1.1	312.3	276.7
3	65115.2	327.2	255.3	351.8	237.4	282.8	1001.7	1.2	332.5	258.8
4	66139.2	321.8	265	318.9	253.6	284.9	962	1.1	314.5	281.6
5	66349.7	321.3	265.4	337.6	259.3	285.1	1082.2	1.4	340.6	271.7
6	66882.7	331.3	258.6	326.2	236.4	286.1	969.3	1.1	324.5	271.8
7	68439.7	323.6	272.8	326	266.6	290.3	1007.5	1.2	333.1	283.4
8	68790.4	334.8	266.1	335.7	247.2	290.3	1132.3	1.5	334.6	291.6
9	72367.4	339.2	272.6	331.8	256.3	298.8	1011.6	1.1	328.2	269.2
10	72928.5	321.1	291.3	333.2	280.2	300.3	1062.6	1.2	343	311.7
11	75088.7	353.6	273	353.2	251.9	303.1	1047.1	1.2	340.8	281.3
12	76715.9	328	299.4	333.4	289.6	307.9	1067.8	1.2	333.5	309.1
13	84402.9	368.9	295.4	384.2	286.5	322.1	1104.8	1.2	386.6	310.8
14	90771.4	370	315.8	395	292.5	335.2	1198	1.3	388.5	325.4
15	91753.3	367.4	320.9	379.8	304.6	337.3	1130.6	1.1	379.8	340.8
16	91795.4	391.1	303.9	378.7	281.4	335.1	1161.9	1.2	382.8	325.3
17	95793.2	402.6	305.4	392.5	278.4	343.1	1183.7	1.2	397.7	313.4
18	96775.1	389.7	318.1	395	281.8	345.7	1152	1.1	386.2	318.2
19	103677	394.6	338.2	419.5	294.5	358.5	1322.5	1.3	404.6	342.8
20	105150	424.8	323.6	431.1	295.9	358.3	1514.3	1.7	429.8	361.9
21	106650	415.7	330.6	423.2	318.9	362.5	1223	1.1	423.2	340.8
22	108095	407.7	344.2	412.8	321.9	365.3	1339.4	1.3	414.1	387.3
23	110017	404.7	349.7	410.3	339.4	369.4	1247.4	1.1	416.7	354.8
24	110760	429.7	333.2	432.3	316.5	368.4	1267.8	1.2	427.6	345
25	120117	433.1	356.9	449.3	352.1	385.7	1317.1	1.1	462.4	375.4

S.disjuncta.seminulina 872C 11H 4 20-22 Hole 1

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)

314	74696	336.9	284.5	328.4	270.1	304	1016.8	1.1	327.3	290
315	85174.4	355.4	306.3	354.2	278.1	325	1061.9	1.1	355.1	301.9
81	86927.9	368.8	302.7	372.3	289.8	328.1	1098.6	1.1	371.8	316.4
78	89368.6	374.7	305.5	366.5	292.1	332.2	1097.2	1.1	367.4	315
7	98542.6	397.1	321.2	397.4	306.5	349.5	1187.2	1.1	400.4	337.7
171	99566.6	369.3	347.9	374.5	323.4	351.2	1173.7	1.1	381.8	353.6
5	100941	395.4	333.4	393.7	320	354.4	1199	1.1	397.4	345.7
80	102428	386.5	342.1	382.6	329.5	358.2	1181.8	1.1	384	347
82	103775	388.5	343	386.1	311.6	358.4	1187.3	1.1	378	346
31	107464	402.9	344.1	406.2	328.1	364.4	1222.4	1.1	409.4	357.7
36	111350	411.7	354.9	423.2	314.1	375.6	1269.3	1.2	416.7	356.3
169	113342	410.9	354.9	407.1	305.7	375.7	1260.7	1.1	402	346.1
6	114660	427	353.1	431.9	327.6	379.3	1301.4	1.2	435.9	370.8
33	116890	428.4	356.1	429.1	336.5	381.8	1296.5	1.1	434.8	366.8
2	119514	402.3	384	414.4	351.8	385.2	1299.5	1.1	420.1	398.4
34	125265	423.6	389	425.7	364.5	398.6	1353.6	1.2	441	394
310	139475	448.1	400	451.8	328.5	416	1416.9	1.1	437.6	395
76	140400	466.3	387	462.4	329.3	418.1	1406	1.1	450.8	383.1
306	140961	454.7	399	465.7	378.1	418.4	1412.3	1.1	469.9	421.2
284	142280	491.6	377.4	496.1	345.9	419.9	1452.5	1.2	496.9	388.8
4	143360	467.3	397.7	492.7	353.4	420.4	1468.4	1.2	497.7	425.5
152	153376	503.9	399.2	515.6	361.5	436.8	1511.6	1.2	522.2	420.3
25	155915	513.7	398.4	516.2	367.1	437.8	1570.7	1.3	520.5	421.6
162	156644	490.6	412.1	497.6	393.7	440.9	1498.3	1.1	500.4	426.5
163	159870	492.9	420.8	505.6	377.2	444.9	1531.2	1.2	508.9	445.4

S.disjuncta.seminulina 872C 11H 4 20-22 Hole 2

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)

1	89354.6	361.6	318.2	367.2	307.4	332.2	1109	1.1	366.8	330.6
2	95582.8	356.7	344.5	362.7	321.7	344.2	1156.2	1.1	360.8	347
3	96256.1	361.8	340.9	370.3	305.9	346.2	1151.5	1.1	353.7	334.7
4	105486	403.3	344.8	404	330.4	364.4	1235.7	1.2	399.5	358.6
5	105542	408.6	336.1	406.2	319.2	363.3	1224.1	1.1	409.8	350.1
6	107562	408	340.3	407.1	323.2	364.7	1237.4	1.1	408.7	356.4
7	109680	389.2	361.5	393.7	332.4	369.3	1217.2	1.1	391.4	366.3
8	110129	409	347.2	415.3	330.7	368.8	1239.3	1.1	417.3	361.3
9	111967	406	356.3	415.5	328.6	371.6	1277.1	1.2	418.3	379.5
10	114871	421.4	349.2	419.1	329.6	377.4	1245.4	1.1	415.8	354.8
11	116007	413.2	367.6	421.8	344.7	382.8	1281.8	1.1	422.1	381
12	116442	414.5	360.2	408.3	314.1	380.5	1267	1.1	407.5	360.2
13	117718	436.5	355.4	437.9	337.6	384.4	1314.8	1.2	438.8	370.9
14	118756	423.4	360.2	430.6	314.8	384	1288.4	1.1	409.6	353.6
15	120229	440.6	355.9	444.4	335.5	387.1	1316.8	1.1	445.6	369.7
16	128968	477.8	348	489.2	331.8	397.6	1374.8	1.2	495.2	371.4
17	128996	461	363	464.4	336.5	400.1	1369.6	1.2	464.8	386.4
18	130020	450.7	372.5	458.5	346.3	400.8	1351.5	1.1	464.5	390
19	130651	453.4	373.1	455.4	348.2	402	1369.2	1.1	458	397.4
20	135673	468.5	376.7	460.2	356.8	411.4	1384.3	1.1	459.9	397.6
21	141733	475.9	386.8	486.8	383.6	418.7	1445	1.2	493.6	407.5
22	142308	493.6	378	495.4	348.7	418.9	1459.4	1.2	500.4	401.8
23	144160	478.3	390.5	478.5	365.2	421.3	1456.7	1.2	478.4	414
24	146474	450.8	424.3	464.4	395.5	429.5	1459.7	1.2	473	444.2
25	146685	477.6	399	481.1	373.5	425	1466.8	1.2	484.2	420.5

S.disjuncta.seminulina 872C 11H 4 20-22 Hole 3

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	98696.9	403.9	314.1	391	274	347.9	1190.5	1.1	387.6	320.8
2	98935.3	400.5	320.8	400.8	301.5	349.6	1201.1	1.2	402.5	343.2
3	103957	419	323.8	419	304.9	359.7	1218.4	1.1	419.4	333.7
4	105739	402.3	340	401.3	323.3	361.4	1213.7	1.1	401.6	354.9
5	106089	407.3	333.6	400.4	312.9	362.3	1195.4	1.1	399	344.4
6	109133	416.7	341.3	419.4	320	369.7	1249.3	1.1	422.1	355.8
7	109751	403.3	352.5	403.3	325	368.2	1255.1	1.1	412.6	365.9
8	110185	422.6	337.5	418.7	310.9	368.6	1349	1.3	416.5	360.6
9	111209	436.1	331.2	428.4	308.2	370.8	1251.8	1.1	429.2	343.7
10	111237	400.8	359.6	402	337.6	370.7	1244.8	1.1	411.1	364.9
11	112612	409.9	354.6	418.7	327.2	373.5	1266.1	1.1	419.5	382.2
12	118027	436.2	352.9	445.7	318.7	382.1	1334.7	1.2	446.2	380.1
13	120846	433.8	360.7	439.5	344.8	385.6	1314.8	1.1	443.5	373.5
14	121141	449.8	347.3	437.9	310.9	386.9	1312.2	1.1	431.3	359.3
15	127201	460.1	356.5	451.3	326.7	395.8	1332.9	1.1	446.9	374
16	127257	460.5	363	465.7	335.9	398	1381.7	1.2	467.8	399.3
17	132503	462.2	370	461.1	352.1	404.1	1370.4	1.1	467.3	386.9
18	132531	429.6	398.4	440.9	360.5	405.9	1389.6	1.2	443.4	412.2
19	134411	467.1	371.1	463.2	335.9	407.1	1373.6	1.1	456.5	380.9
20	135757	482.8	363	481.5	330.9	408	1408.9	1.2	478.2	378.8
21	136304	484.5	362.9	478.5	335	409.8	1388.2	1.1	476	375.3
22	136936	445.1	398.5	453.2	360.5	414.5	1390.6	1.1	448.8	395.7
23	140807	461.9	396.7	471.1	372.8	419.7	1418.1	1.1	472.5	417.4
24	152534	493.2	402.6	483	360.1	435.8	1483.6	1.1	484.6	417.6
25	154624	457.3	436.5	476.7	386.9	438.1	1492.4	1.1	465.1	450.8

S.disjuncta.seminulina 872C 11H 4 20-22 Hole 4

1	57372.1	294.1	253.7	303.4	240.9	267.6	881.7	1.1	302.4	273
2	57484.3	299.5	249.9	296.5	244.6	268.6	887.1	1.1	292.2	258.6
3	57849	291.1	255.1	294.9	243.5	267.4	877.7	1.1	296.2	264.1
4	59925.1	283.4	272.6	289.3	246.3	272.8	890.8	1.1	284	275.6
5	86507	353.3	314.3	359.6	289.9	327.6	1095.7	1.1	361.7	324.6
6	89733.3	379.3	305.1	375.4	285.2	331.9	1122	1.1	377.8	316.9
7	91402.6	382.3	306.9	377.6	292.7	335.7	1124.9	1.1	377.7	317.3
8	92651	382.8	310.6	378.4	284.6	337.7	1131.1	1.1	372.5	323.8
9	96831.2	370.3	335.4	376.8	318.9	346.5	1142.1	1.1	376.8	341.6
10	101867	399.9	330.1	409	300.8	354	1202.4	1.1	410.5	344.8
11	102288	391.8	337.9	394	313.7	354.9	1201.8	1.1	400.5	350.5
12	102456	399.8	327.6	400.8	298.2	356.3	1172.3	1.1	399.8	337.7
13	103396	398.4	334.2	397	314.1	356.9	1209.6	1.1	399.1	352.2
14	107296	383	358.9	389.8	317.8	365.4	1220.1	1.1	381.3	363.2
15	110045	430.9	328.2	445.1	301.1	367.7	1284.1	1.2	441	340.8
16	113482	449.3	330.2	442.9	309.4	374.2	1291.2	1.2	445.2	345.2
17	117550	433.3	350.4	428.9	320.7	379.9	1313.6	1.2	429	378.7
18	120229	408.6	381.6	428	354.9	387.7	1293.5	1.1	431.9	398
19	129964	455	366.1	448.8	335.7	401.3	1328.4	1.1	446.4	371.5
20	149125	512.2	375.8	497.3	331.1	427	1472.5	1.2	495.5	390
21	158005	463.4	438.4	479.5	377.9	443.9	1492.9	1.1	474.7	457
22	165972	534.5	405.4	531.9	370.2	452.4	1595.9	1.2	528.1	423.4
23	166043	506.5	425	509.4	391	452.5	1592	1.2	515.8	455.5
24	171359	535.3	414.1	535.6	379	458.7	1596.3	1.2	536.7	437

G.woodi 1137A 8R CC Hole 1

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	39417	236.1	214	239.7	205.2	220.8	716.2	1	240.4	221.7

2	40946	249.6	209.9	251.2	201.3	224.3	734	1	252.9	221.1
3	42909.9	243.9	225.9	247.6	209.5	229.8	751.4	1	243.5	232.4
4	45701.3	255.3	229.1	254.7	217.9	237.5	770.6	1	254.3	233.8
5	46557	266.4	224.6	269.7	214.4	239	835.6	1.2	269.5	231.9
6	47300.4	257.7	235.8	257	211.9	241.3	793.5	1.1	251.7	238.4
7	47454.7	271.9	224.5	271.2	198.5	241	799.8	1.1	272.3	227.8
8	48829.4	266.7	235.4	272.6	225.5	244.9	811.3	1.1	270.9	243.9
9	49418.6	253.9	249.9	263.5	230.4	246.8	811.1	1.1	266.2	259.8
10	49993.7	265	241.8	269.1	217.4	248.2	816.4	1.1	258.4	237.5
11	50105.9	276.1	232.1	278.4	215.3	248.4	811.9	1	276.6	239.9
12	50933.5	281.1	232.1	284.5	213.5	249.9	826.5	1.1	280.8	237.1
13	51438.5	287.7	230	288.1	217.2	250.7	838.8	1.1	288	236
14	53290.1	269.9	253.2	271.8	234.6	256.1	839.1	1.1	272.3	262.1
15	53696.9	283.5	243.5	278.9	226.1	256.3	872.3	1.1	277.7	250.7
16	54720.9	285.7	245.4	290.7	236.5	259.9	854.9	1.1	292.4	262.2
17	59939.1	293.6	261.9	296.2	244.2	272.1	894.3	1.1	292.9	270.4
18	60037.3	304.3	252.5	308.2	247.3	271.9	893.6	1.1	307.8	263.8
19	61257.7	295.1	266.7	299.6	246.4	274.5	916.6	1.1	301.3	279
20	63123.3	319.2	254	312.9	219.8	278.1	929.7	1.1	311.4	250.2
21	63417.9	313.8	261.2	320	247.6	278.9	943	1.1	321.1	273
22	64736.5	320.1	259.3	320.3	248.3	282.3	938.3	1.1	320	271.4
23	65634.3	304.3	276.6	334.5	255.6	285.1	1026.6	1.3	304.6	282.7
24	66433.8	322.2	265.2	319.6	244.5	285.5	959.7	1.1	317.2	279.2
25	74162.9	327.2	291.2	337	267.4	302.8	1004.8	1.1	337.9	310.7

G.woodi 1137A 8R CC Hole 2

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	36120.6	232.3	199.3	230	191	210.4	688.1	1	228.9	206.8

2	37298.9	243.2	196	244.2	179.2	213.5	698.8	1	245.4	195.9
3	39403	250.1	202.2	244.6	182.9	219.4	724.5	1.1	243.7	207.1
4	39725.6	237.6	214.2	242.1	206	221.7	722.6	1	244.4	223.5
5	40328.8	239.3	217.1	238.4	206	222	738.5	1.1	232.9	221.5
6	41030.2	245.1	214.8	248.2	202.4	224.2	736.4	1.1	247.8	223.4
7	41254.6	252.1	209.8	245.2	187.3	224.6	741.1	1.1	243.9	213.3
8	41647.4	236.9	225.5	247.7	207.8	226.3	744	1.1	242.7	231.9
9	43891.8	255.5	219.4	259.2	209.4	232.5	753.8	1	260.8	232.8
10	44200.4	242.9	233.2	251.9	222.5	233.3	758.5	1	248.1	233.3
11	47005.9	248.6	242.7	279.7	224.5	241	834.5	1.2	241.1	239.6
12	48366.5	254.1	243.8	259.8	226.4	244	796.9	1	260.8	247.6
13	48717.2	264.8	235.8	268.5	224.5	244.6	806.3	1.1	264.2	244.8
14	50807.3	268.5	242.9	274.3	227.8	249.8	824.8	1.1	275	256.8
15	51620.9	261.4	253.6	263.9	234	252.2	833.8	1.1	262.8	252.9
16	52196	282.3	237.4	276.2	218.8	252.9	838.8	1.1	271.8	240.8
17	53163.9	275.3	247.8	279.1	218.4	255.4	846.8	1.1	268.2	245.4
18	53402.4	291.5	235.3	287.2	210.3	255.6	853.7	1.1	284.4	233.6
19	54917.3	269.1	262.8	273.4	248	260	861.6	1.1	278.4	271.1
20	55871.2	274.8	260.4	283.4	248.3	262.8	857.1	1	282.9	271.7
21	56179.8	299.4	242	292.8	211.4	262	875.1	1.1	290.5	243.1
22	60752.7	309.4	250.9	307.5	232.8	273.3	895.1	1	305.9	251
23	63684.4	310.3	263.8	309.4	249.3	279.4	933.9	1.1	307.7	275.5
24	68552	320.5	275.6	323.3	254.7	290.1	973.8	1.1	322.3	288.6
25	76954.4	352.2	280.3	354.7	255.6	307.2	1029.8	1.1	351.6	294.9

G.woodi 1137A 8R CC Hole 3

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	33735.9	227.9	189.3	222.1	176.1	203.2	661.5	1	222.2	189.7

2	35713.8	231.7	197.2	227.5	187.6	209	679	1	227.3	201.7
3	35755.9	232.5	197.5	233.7	187.6	209	692.6	1.1	233.5	203.1
4	40469.1	250.5	207.1	242.9	186.6	222.2	758.2	1.1	239.9	225.6
5	40567.3	241.6	216.4	243.1	202.6	223	741.1	1.1	245.8	229.7
6	41016.1	250.7	209.7	247.3	191.9	223.9	752.9	1.1	244.8	208.1
7	41745.6	246.1	217.9	244.9	209.9	226.9	745.6	1.1	246.4	225
8	42250.6	254.3	213.5	253.2	202.7	227.5	748.1	1.1	255.5	218.4
9	44004	271.2	207.2	267.2	187.3	231.8	760.9	1	266.9	204.3
10	44018	260.5	217	258.4	203.7	232.1	766.6	1.1	259.8	219.8
11	44032	253.3	222.2	252.3	210	232.6	756.2	1	251.7	230.5
12	44649.3	264.4	216.4	262.3	207.8	233.9	777.9	1.1	263.9	225.8
13	45967.8	253.6	233.1	259.3	213	237.5	785.7	1.1	259.1	243.9
14	46023.9	272.4	216.9	265.7	194.8	237.1	790.4	1.1	262.8	219.8
15	46500.9	274.6	216	273.4	210	239	779.4	1	273.9	225.7
16	46571	278.3	215.8	275	194	237.7	803.5	1.1	276.4	215.7
17	47005.9	271.8	222.3	266.4	202	239.5	797	1.1	268.2	229.8
18	48464.7	261.3	237.8	266.7	219.4	244.8	797.1	1	261.9	235.3
19	48871.5	265	236.5	260.9	224.4	245.2	806.9	1.1	258.2	244.2
20	49194.1	287	220.4	280.9	203.7	244.4	821.1	1.1	281.9	223.3
21	50260.2	260.3	247.9	263.7	231.7	249.1	814.6	1.1	257.9	249.1
22	51270.2	282.6	232.6	275.5	213.1	250.6	825.5	1.1	271.7	233.6
23	54370.2	289.3	241.9	286.7	218.8	258.4	864	1.1	281	247.4
24	63726.5	321.7	254.6	319	241.1	279.4	970.1	1.2	320.4	266.1
25	64526.1	300.5	274.8	305.6	257.6	282.6	921.6	1	302.6	274.7

G.woodi 1137A 8R CC Hole 4

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	27283.3	203	171.8	199.1	161.7	182.6	595.6	1	199.9	174.7

2	28433.6	211.7	171.5	210.3	164.8	186	605.8	1	213.1	173.1
3	32768	237.4	178	226.2	149.5	198.7	673.1	1.1	228.2	180
4	33413.3	227.6	188.7	227.8	177.7	201.8	666.4	1.1	226.6	192.7
5	33960.4	227.7	191.1	223	180	203	667.7	1	221.3	195
6	34170.8	221.3	198.9	222.8	187.7	204.1	675.7	1.1	221.2	202.5
7	35531.4	228.4	200.3	229.6	184.4	208.6	690.3	1.1	226.8	206.4
8	35699.8	228.3	201.1	229.6	188.1	208.7	689.3	1.1	226.6	204.3
9	35924.2	222.5	206.9	226.7	189.3	209.8	686.8	1	226	217.7
10	36597.5	240.2	195.3	234.6	176.1	213.1	702.7	1.1	234	201.7
11	36611.5	241.5	194.6	238.2	177.6	211.3	698.6	1.1	237.9	197.7
12	37172.6	242.4	196.7	239	171.2	212.8	705.6	1.1	232.9	196.2
13	38940.1	228.1	219.4	227.5	204.8	218.9	718.6	1.1	233	219.6
14	39487.2	250	203	249.3	189.9	219.3	729.1	1.1	247.9	207.3
15	40244.6	249.2	207.3	249	179.8	221.5	740.8	1.1	243.4	210
16	41549.2	247.5	214.8	244.9	202.2	226.3	737.3	1	241.4	215.8
17	41970	246.8	219.5	250.9	206	226.6	755.1	1.1	252.7	223
18	43723.4	256.8	218.6	257.2	208.7	231.6	761.4	1.1	257.2	222.4
19	44621.2	273.5	209.9	270.3	189.9	232.9	787.3	1.1	269.1	214.2
20	45056	263.6	219.7	259.4	206	234.7	809	1.2	255.4	232.1
21	45420.8	247.7	234.7	251.9	218.1	236.5	774.5	1.1	252	240.4
22	46332.5	256.7	231.1	255.6	220.3	238.7	780.5	1	253.4	235.7
23	47538.9	276.3	220.4	272.2	199.1	241.2	799.9	1.1	273	225
24	48170.1	256.3	241.4	260.8	226.7	244	796.9	1	259.1	248.3
25	48661.1	273.4	228.2	271.2	206.5	244.3	804.4	1.1	266.9	228.5

G.woodi 1137A 3R CC Hole 1

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	33792	224	195	227.5	183.6	203.2	680.8	1.1	228.9	197.1

2	38084.4	232	209.9	236	188.9	216.4	704.2	1	235.5	214.9
3	39557.3	233.7	217	237.4	202.6	220.6	722.2	1	240.1	225.2
4	40427	230.4	225.4	236	205.3	222.7	732.8	1.1	238.1	230.8
5	42376.8	242.6	224	242.8	210.9	228.4	743.6	1	245.4	220.4
6	43162.3	253	219.5	256.9	201.2	229.7	779.1	1.1	258.3	236.7
7	43485	266.6	209.7	266.7	186.3	230.1	765.5	1.1	265	210.2
8	43597.2	251.5	223.6	251.4	196.6	231.1	774.2	1.1	246.1	229.4
9	44354.7	267.7	213	262.2	193.3	233	776	1.1	262	217.5
10	44803.6	260.7	220.4	258	199.9	234.5	782.6	1.1	254	222.7
11	48324.4	255.7	242.5	264.5	224.5	244.1	805.8	1.1	266.4	254.5
12	49797.3	269.5	237.1	273.7	221.8	247.6	820.4	1.1	268.7	246
13	50975.6	289.5	226.5	292.1	212	249.3	845.4	1.1	295.6	229.3
14	53023.6	275.8	248.1	282.1	233.1	255.3	861.4	1.1	286.2	259.6
15	54454.4	269.9	260.4	280.7	238.9	258.7	882.9	1.1	274	264.8
16	54636.8	269.8	260.7	272	242.9	259	854.3	1.1	268.4	261.1
17	56278	297.8	242.7	294.1	217.4	262.6	874.5	1.1	292.1	246.9
18	57091.6	301	244.9	301.5	221.8	264.5	936.9	1.2	298.1	251.9
19	57863.1	311.5	237.7	302.7	217.7	266	885.1	1.1	301.3	240.9
20	58999.3	310.4	243.9	309.4	229	268.9	898	1.1	308.6	252.5
21	60331.9	285.3	272.1	293.8	251.7	272.6	909.6	1.1	294.1	282.9
22	60879	311.7	251.9	308.2	224.8	273	915.7	1.1	305.1	249
23	61874.9	290.3	273.9	301.5	232.7	276.9	933.3	1.1	282	274
24	63768.6	296.2	278	304.7	256.4	280.1	945.1	1.1	303	281.3
25	64021.1	326.8	252	317	222.8	279.8	946.9	1.1	313.2	259.7

G.woodi 1137A 3R CC Hole 2

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	28882.4	207.1	179.6	204.8	163.8	188.1	624.4	1.1	200.6	182.7

2	31968.5	211.3	194.5	213.7	182.6	198	652.7	1.1	213.3	198.2
3	32866.2	226.8	185.9	224.8	174.4	201.8	667.1	1.1	226.9	191.9
4	33932.3	220.1	198	225.8	182.9	204	675.6	1.1	227.2	208.6
5	34858.1	236.7	188.6	237.2	175.4	207.1	682	1.1	238.1	195.2
6	35026.4	234.2	191.9	230	181	206.6	685.4	1.1	230.1	196.5
7	36373.1	243	192.8	239.7	172.3	210.3	704.5	1.1	237.1	192.8
8	36555.4	240.4	195.1	241.1	186.6	211.9	702.1	1.1	240.3	206.3
9	36765.8	227.4	208.1	226.3	194.3	211.8	700.7	1.1	228	207.9
10	36990.3	223.6	212.8	232.7	193.3	213.4	707.2	1.1	225.7	212.6
11	37621.5	228.5	211.7	230.2	199.5	214.8	710.2	1.1	232.1	221.4
12	38505.2	246.3	200.9	245.8	183.2	216.9	728.4	1.1	246.7	211.2
13	40651.4	246.9	211.3	249	200.5	223.6	741.5	1.1	248.5	222
14	40693.5	239.3	218.3	246.2	203.5	223.4	742.7	1.1	246.3	227.8
15	41801.7	262.7	203.4	256.4	177	226.1	749.8	1.1	258.4	203.5
16	45308.5	243.1	240	251.9	219.8	236.3	793.6	1.1	251.3	243
17	46108.1	267.3	221.7	267.4	211.5	236.9	801.6	1.1	265.8	232.5
18	46472.8	265.4	224.7	273.8	212.8	239	797.3	1.1	274	239.7
19	46711.3	246.2	244.5	256.4	221.2	239.7	801.5	1.1	249.5	246.5
20	48296.4	282.1	219.2	278.4	202.3	242.8	805.6	1.1	279.1	228.4
21	48548.9	277.1	226.5	270.3	206	243	823.2	1.1	269.2	230.8
22	50709.1	272.9	239.2	275	217.2	249.5	833.5	1.1	273.6	250.4
23	50737.1	281.8	233.4	280.9	214.4	248.8	840.7	1.1	279.6	237.1
24	52013.6	277.6	240.9	275	223.9	252.8	848.5	1.1	274.2	251.5
25	59237.8	304.4	250	304.7	232.1	269.9	897	1.1	303	260

G.woodi 1137A 3R CC Hole 3

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	30621.8	208.6	188.4	210.9	170.2	194.4	634.8	1	205.2	192.1

2	33329.1	224.8	190.7	224.7	180.7	201.8	668.7	1.1	225.4	196.1
3	37691.7	228.6	212.5	229.9	198.2	214.6	716.7	1.1	225.6	216.6
4	37761.8	228.3	211.8	229.7	191	215.2	702.6	1	221.4	207.1
5	37944.1	248.9	195.3	242.1	175.4	215.5	711.2	1.1	239.6	192.3
6	38954.1	238	210.7	241.6	196.6	218.8	729.9	1.1	244.3	218.7
7	39136.5	233.4	215.1	238.9	197.4	219.3	724.4	1.1	230.4	211.2
8	40104.4	243.4	212	243.4	196.6	222.3	735.7	1.1	246.2	218.6
9	40875.9	274.2	191.3	269.1	158	221.9	770.4	1.2	259.3	182.7
10	40875.9	252.3	207.9	249	187.3	223.5	745.6	1.1	247.5	208.5
11	40960	240.9	219.2	245.4	201.3	223.5	755.5	1.1	240.5	221.7
12	41675.4	270.1	197	266	179.8	225.4	747.2	1.1	266.2	191.8
13	42376.8	261.9	207.6	256.4	183.6	227.1	757.4	1.1	258.5	206.5
14	46402.7	269.2	221.2	264.5	206	238.3	783.6	1.1	263.8	220.8
15	50540.8	284.3	228.7	286.5	220.3	248.5	831.6	1.1	286.8	236.4
16	51761.1	271.6	244.1	277.5	233.6	253	823.1	1	277.9	254
17	52504.6	275.4	246.5	281	236.9	253.4	855.9	1.1	281.4	251.6
18	53023.6	287	237.8	283.8	217.9	254.7	855.7	1.1	276.4	243.2
19	53234	293.7	233.3	293.3	219.2	255	858.4	1.1	293.6	243
20	56320.1	282.7	255.7	289.9	246.2	263.7	872.1	1.1	290	266.3
21	58368.1	290.6	257.2	291.5	239.3	268.2	876.9	1	284	262.9
22	59321.9	317.2	240	312	217.3	269	907.9	1.1	309.5	246.9
23	59350	288.9	263.7	287.1	238.9	270.5	892.2	1.1	284.9	263.1
24	59798.9	296.1	259	301	249.6	271.5	900.5	1.1	308.5	274.6
25	72367.4	340.2	275.1	356.1	253.3	296.7	1151.2	1.5	339.9	291.8

G.woodi 1137A 3R CC Hole 4

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	27395.5	218.3	160.1	215.1	150.2	181.5	598.6	1	213.6	157.6

2	29822.3	202.2	189.5	203	176.7	191.5	625.9	1	197.4	187.6
3	31926.4	228.7	180.2	224.8	164.8	197.3	651.9	1.1	222.9	184.4
4	32641.8	227	184.7	224.8	162.6	199	664.6	1.1	220.8	188.9
5	33792	229	189.5	230	180.1	202.9	672.8	1.1	231	196.8
6	34858.1	220.5	202.6	222.1	183.9	207	676.7	1	219.1	206.1
7	36667.7	246.6	191	244.9	180.1	211	702.6	1.1	244.3	195.7
8	37607.5	233.2	208.4	233.7	190.8	213.5	718	1.1	230.4	216.3
9	39080.4	228.6	219.7	236.7	202.4	218.5	724.4	1.1	237.4	227
10	43386.8	251	222	255.3	194	231.3	765.4	1.1	248.6	227.1
11	44424.8	264.2	215.7	263.6	194.8	233	785.6	1.1	262.1	224.5
12	44817.6	262.4	220.2	264.4	209.5	234.6	779.6	1.1	269	229.4
13	44859.7	263.6	219.1	263.5	197.9	234.2	788.4	1.1	256.1	220.7
14	45266.5	246.5	236.1	252.3	217.2	236.3	779.6	1.1	254.9	248.7
15	45420.8	256.4	227.4	260.8	217.4	236.1	780.5	1.1	259	232.5
16	46080	260.6	228.5	264.6	216.1	237.5	796	1.1	266.8	239.1
17	46178.2	262.3	226.8	263	210.9	237.6	794.9	1.1	262.6	236.7
18	46206.3	255	232.8	260.8	221.1	238.3	789.5	1.1	260.9	239.4
19	47651.1	256.3	238.9	260.6	212.9	241.7	802.4	1.1	259.7	242
20	48184.2	262.9	236.4	267.2	222.5	243.3	811.8	1.1	268.9	245.3
21	52616.8	277.7	244.2	282.8	226.5	254.2	853.9	1.1	282.1	255.3
22	55211.9	293.1	242.7	285.2	219.2	260	868.1	1.1	283.2	246.5
23	59869	297.1	259	296.7	235.8	271.6	901.5	1.1	290.7	262.3
24	60037.3	305.7	251.9	305.2	240.4	271.3	902.2	1.1	304.9	265.3
25	64932.9	332.2	251.6	320.3	213.7	281.5	948.3	1.1	315.7	252.1

G.woodi 1137A 11R CC Hole 1

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	31365.3	220.5	181.9	221.9	171.8	196.3	645.7	1.1	221.2	187.7

2	34226.9	235.5	186.8	229.6	168.5	203.9	677.2	1.1	229.7	187.4
3	38505.2	241	204.8	241.6	193.3	217.3	711.7	1	239.1	211.9
4	39894	232.6	220.2	241.1	199.5	221.5	730.9	1.1	244.2	233.4
5	42867.8	267.2	205.6	267.1	191	228.5	759.8	1.1	267.7	211.7
6	42980	275.4	199	272.7	188.6	229.1	760.8	1.1	273.7	203.5
7	43414.8	261.6	212.1	255.6	199.1	230.4	751.9	1	254.6	209.9
8	44943.8	262.9	219.7	266.5	210.9	235	783	1.1	266.1	230.2
9	45897.7	263	224.1	257.1	214.5	237.3	791.7	1.1	256	234.7
10	46879.6	268.4	223.8	261.9	195.7	239.7	793.1	1.1	257.6	224.6
11	47693.2	275.1	221.2	275.5	206	241.7	787	1	273.9	218
12	48254.3	258.4	240.5	265.5	227.8	243.3	803.4	1.1	268.9	249.2
13	48997.7	274.8	230.4	271.8	211.1	244.9	824.1	1.1	272.6	242.5
14	50428.5	283.8	228	276.3	194.8	248.1	819.9	1.1	269.8	221.1
15	50849.4	281.1	232	274.9	213.5	249.8	823.2	1.1	271.2	233.1
16	51087.8	261.9	250.7	273.4	210.6	250.9	838.8	1.1	262.6	255.4
17	52967.5	272.2	249.9	278.4	229.6	255.3	844.6	1.1	281.6	264.4
18	57484.3	287.7	256.7	289.1	244.5	266.3	884.5	1.1	288.7	268.8
19	58213.8	301.3	248.1	294.1	231.6	267.2	888.8	1.1	291	254
20	61117.4	300.5	261.1	299.8	236.9	274.5	908.9	1.1	295.4	262.7
21	63011.1	296.8	273	300.7	260.2	278.6	916.1	1.1	302.4	281.1
22	63572.2	317.9	257.3	319.8	228.7	279.5	942.2	1.1	320	267.7
23	66181.3	316.2	269.2	315.4	243.4	285.1	956.4	1.1	309.3	272.7
24	73223.1	337.6	278.4	339.4	259.8	300	1003.1	1.1	339.7	296.3
25	96073.7	387	319	389.5	296.2	344.2	1157	1.1	388.8	336.2

G.woodi 1137A 11R CC Hole 2

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	28742.2	210.6	175.9	210.9	163.6	188.2	627.2	1.1	209.3	179.3

2	34437.3	228.3	193.8	227.8	178.1	205.1	678.4	1.1	228.4	201.5
3	38771.8	235.2	211.7	233.6	194.8	217.9	713.7	1	231.4	216.4
4	39683.5	249.3	203.7	247	192.3	220.1	721.5	1	247.3	207.6
5	40272.7	253.9	204.1	249	190.3	221.7	742.1	1.1	251	210.1
6	41016.1	259	202.8	258	189.1	224.7	743.3	1.1	258.5	213.3
7	41984	257.2	209.4	253.9	189.9	226.8	751.8	1.1	244.5	209.6
8	43414.8	271.2	204.7	271	199.7	230.1	763.5	1.1	270.8	210.9
9	43597.2	246.3	227.6	248.9	209.7	231.2	772.9	1.1	246.2	240.8
10	45953.8	258.8	227.4	256.4	211.1	237.6	775.1	1	254.5	232.9
11	47033.9	269.6	223.9	271	206	239.9	798.2	1.1	265.3	230
12	47062	260.5	231.4	263.7	223.4	240.4	793.8	1.1	262.3	238.6
13	48591	271.5	229	272.8	215.6	244.5	800.8	1.1	273.1	231.9
14	48843.4	257.6	242.9	256	225.5	245.6	795.1	1	256.7	239.6
15	52280.2	266.2	251.7	270.9	236.9	254.1	827.7	1	273.1	259
16	54117.8	283.7	244.8	283.6	231.7	258.1	851.1	1.1	285.8	252.7
17	55436.3	287.3	247.9	295.3	237.3	261.4	866.7	1.1	294.6	260.2
18	56853.1	297.4	245.6	299.9	228.7	264.1	886.1	1.1	299.8	258.5
19	59153.6	298.5	254	294.1	231	269.7	887.2	1.1	287.5	259.9
20	60864.9	303.6	257.9	302.7	232.7	273.3	909.3	1.1	303.6	267.1
21	62099.3	300.5	265.6	306.3	251.6	277.1	913.2	1.1	301.7	272.2
22	63460	299.4	273.3	308.6	258.3	279.6	930.8	1.1	310.5	282.5
23	63558.2	313.8	259.7	316	247.2	279.8	920.6	1.1	315.8	274.1
24	64512.1	319.4	260.1	318.6	239	281.6	941.4	1.1	317.9	265.6
25	66279.5	322	264	327	253.5	285.7	950.3	1.1	328	278.5

G.woodi 1137A 11R CC Hole 3

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	24618.1	195.7	160.9	190.3	147.2	172.8	564.8	1	190.7	161.3

2	25964.7	195.7	169.8	192.8	157.9	177.5	580	1	192	172.3
3	30313.2	211.4	183.8	208	171.9	192.5	630.7	1	202.3	184.1
4	33062.6	207.7	203.7	211.7	190.8	202.1	653.1	1	211.2	205.8
5	33750	227	190.5	224.4	175.6	202.9	668.6	1.1	222.4	192.4
6	34325.1	232.2	189.9	234.6	171.8	204.5	690.5	1.1	225.3	186.8
7	37397.1	245.4	196.2	239.3	171.9	214.3	712.9	1.1	236.6	196.5
8	40988.1	266.8	197.4	262.2	175.4	222.5	748.7	1.1	263.4	201.1
9	41703.5	246.2	217.6	243.1	201.3	226.1	744.5	1.1	238.6	219.4
10	41885.8	266.1	202.5	256	171.2	225.5	776.3	1.1	256.9	206.2
11	41942	241.6	222.1	248.3	212.8	227.4	740.1	1	248.6	231.8
12	42713.5	260.5	211.2	256.5	194	228.4	765.3	1.1	258.5	213.1
13	43316.6	254.7	217.9	251.4	202.3	230.5	757.4	1.1	251.8	222.9
14	43485	256.1	217	260.2	209.7	231.3	751.4	1	259	218.9
15	44256.5	243.8	232.8	245.5	217.9	233.5	762.2	1	241.1	237.2
16	44270.5	260.7	217.9	258.7	205.2	232.9	765.8	1.1	258.4	221.8
17	44607.2	266.2	214.3	267.4	201.3	234.3	774.1	1.1	268.8	221.5
18	45855.6	261.1	224.9	254.3	209.4	237.3	773.4	1	251.7	225.3
19	46767.4	250	240.8	253.2	227.8	239.8	791.7	1.1	251.1	244.4
20	47132.1	266.6	226.4	263	207.7	240.6	794.8	1.1	261	236.8
21	50807.3	272.2	239.4	269.2	222.6	250.2	815.8	1	262.2	236
22	51396.4	286.7	230.6	278.4	205.2	250.4	836.3	1.1	274	232.1
23	52672.9	270.6	250	276.2	236.9	254.7	834.6	1.1	276	261.4
24	53079.7	279.9	243.3	279.6	221	255.5	861.3	1.1	276.9	246.9
25	62534.2	301.9	264.8	305.2	251	278	905.9	1	306.5	273.6

G.woodi 1137A 11R CC Hole 4

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	20732.5	182.8	145.1	182.3	129.8	160.8	523.7	1.1	181.8	145.6

2	28854.4	223.8	164.6	221.8	160.9	188.5	614.2	1	222.7	168.3
3	29668	200.5	189.9	207.7	169.6	190.6	626.4	1.1	207	199.7
4	30215	216.8	178.3	215.3	157.3	191.9	631.6	1.1	210.7	180.2
5	34030.5	226	192.2	219.7	178.1	203.8	660.9	1	217.5	189.7
6	34535.5	236.4	187.6	235.1	177.6	205.1	681.9	1.1	234.6	191.4
7	35040.5	225.8	198.5	228.7	191	207.2	673.5	1	230.8	203.5
8	35278.9	234.7	192.9	228.8	172.9	207	689.9	1.1	225.1	195.1
9	36569.5	236.2	198.5	234.5	187.3	211.6	694.7	1.1	235.2	204.6
10	37817.9	232.9	208.4	234.6	197.7	215.3	705.4	1	232.3	209.8
11	39304.8	240.2	209.9	236.9	199.1	219.4	720.9	1.1	238.1	217.3
12	39641.5	264.6	191.8	258.7	181.2	220	732.6	1.1	261.6	198.1
13	39725.6	226.6	224.6	233.3	207.7	221.4	717	1	233	231.3
14	42068.2	246.7	219.6	248.4	204.4	227.1	750.4	1.1	247.1	225.3
15	43134.3	248.6	221.9	252.6	199.5	231.6	749.3	1	249.1	222.2
16	44438.8	259.5	219.5	258.7	202.2	233.6	763.2	1	257.5	218.3
17	45392.7	255.8	227.6	260.2	216.7	236.2	774.4	1.1	260.8	239.8
18	46388.6	263.5	227.1	266.4	217.7	238.7	793.4	1.1	269.7	229.8
19	52294.2	272.8	246.4	276.2	224	253.6	844.1	1.1	274.9	259.3
20	52336.3	269.3	249.1	271.3	223.9	253.7	835.3	1.1	263.7	246
21	54286.1	280.3	248.6	285.2	225.5	258.2	849.3	1.1	286.1	259.4
22	56670.7	287.4	253	293.2	238.6	264.4	874.1	1.1	297.4	269.3
23	57722.8	297.9	248.3	296.8	235.7	266.8	879.1	1.1	299.5	260
24	61398	311.7	252.5	307.1	225.5	274.4	916.6	1.1	303.3	251.2
25	65942.9	306.3	276.4	312.3	260	285.5	938.3	1.1	312.2	284.9

T.truncat GLOW3 BxTop Hole 1

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	148536	463.5	410	471.8	391.6	430.4	1404.6	1.1	472.3	426.7

2	156336	476.1	421.1	479	401.8	441.3	1448	1.1	465	420
3	169297	478.5	453.1	488.5	389.3	459.4	1560.5	1.1	488	468.6
4	184727	513.4	461.4	524.4	414.7	480	1581.5	1.1	527.5	483.9
5	185442	514.4	461.7	517.2	443.6	481.1	1590.2	1.1	506.6	460.5
6	200213	524.8	487.5	530.3	460.4	500.5	1621.3	1	518.1	495.1
7	202907	559.6	465.1	567.8	429.1	502.2	1687.1	1.1	568.5	489.8
8	215349	570.1	485.7	579.8	465.2	518	1722.5	1.1	578.7	521.2
9	217243	570.3	488	568	465.2	520.2	1734.1	1.1	557.1	496.9
10	222110	582.4	488.9	572.1	451	525.8	1755.5	1.1	572.7	500.7
11	225056	562.4	513.4	579.4	486.7	530.1	1758.9	1.1	532.9	503.5
12	225070	585.9	492.4	583.8	475.7	529.4	1743.8	1.1	566.9	489.3
13	231873	598.4	501	605.4	440.4	537.8	1806.7	1.1	608.1	532.3
14	247444	623.7	508.9	620.7	479	555	1872.9	1.1	619.7	533.7
15	247822	625.1	515.7	658.5	466.1	553.7	1923	1.2	646.5	545.4
16	261822	620.6	545.6	620.2	512.6	575	1924.5	1.1	614	547.9
17	285528	638.2	574.3	651.7	544.6	599.1	1986.8	1.1	620.2	561.3
18	303104	681	569.8	676.6	519.5	615.5	2052.9	1.1	677.1	574.3
19	325043	686.3	611.1	685.5	549.9	639.7	2119.2	1.1	687.8	615
20	365849	724	648.4	742.8	573.6	677	2325.3	1.2	723.8	649.8
21	157879	478.6	422.8	479.1	411.4	443.5	1464	1.1	477.9	430.6
22	218814	588.1	483.2	611.9	430.1	520.7	1811.3	1.2	598.1	496.1
23	228577	584.1	510.4	588.1	486.9	539.8	1772.2	1.1	582.2	523.1
24	244329	616.8	510.7	623.3	458.5	550.7	1863.3	1.1	616	515.5
25	317693	691.1	597.4	713.2	550.7	633.7	2097.2	1.1	698.5	614.6

T.truncat GLOW3 BxTop Hole 2

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	136529	451.2	389	461.3	355	411	1465.9	1.3	436.2	376.3

2	157416	480.6	418.8	479.5	395.8	442.8	1452.4	1.1	464.7	412.6
3	157780	482.6	418.4	484.9	379.5	444.1	1470.2	1.1	474.2	415.5
4	162381	482.9	430.7	483.4	409.2	450.1	1474.7	1.1	466.4	419.8
5	175932	510.1	441.9	512.6	393.7	468	1543.2	1.1	511	460.1
6	188458	514.7	469.2	527.3	422.1	485.3	1588.3	1.1	525.2	490.3
7	201995	538.3	481.9	564.6	454.1	501.7	1676.2	1.1	518.8	473.1
8	210257	559.5	481.1	566.8	440.8	512.4	1716.7	1.1	564.4	499.2
9	211856	582.1	466.4	573	447.6	513	1709	1.1	576.5	480.6
10	212024	562.3	483.8	566.3	453.3	514.3	1713.9	1.1	546.9	477.6
11	215068	567.3	486.4	573	420.4	517.4	1725.1	1.1	574.5	509.5
12	221044	554.9	508.7	561.4	492.9	526.1	1695.3	1	554.3	508.9
13	230162	591.2	498	582.2	479.9	536.3	1757	1.1	573.1	494.6
14	246672	620.3	511.1	616.1	460.7	553.2	1890.4	1.2	608.6	524.8
15	248089	618.4	524	618.1	493.3	562.3	1885.1	1.1	612.9	536
16	255201	614.7	532.1	630.5	478	565	1870.9	1.1	632.3	554.6
17	257361	604.1	552.9	630.9	533.8	577.4	1885.5	1.1	632.1	577.2
18	274839	653.4	546.2	651.7	497.4	588.8	1965.8	1.1	643.5	561.4
19	390804	769.5	651.3	778.6	603.7	699.1	2355.6	1.1	772.8	671
20	408703	771.8	685.6	789.8	628.3	719.2	2448.8	1.2	789.8	703.5
21	175693	490.6	456.8	499.3	439.3	469.1	1524.8	1.1	495.1	459.4
22	227988	602.2	485.4	604.5	433.2	532.9	1811.4	1.1	607.8	512.4
23	237007	577.6	526.1	590.3	481.5	544.4	1794.9	1.1	593	549.2
24	237414	604.5	504.4	602.2	473.7	544.9	1804.1	1.1	579.2	502.2
25	298952	672.2	573.4	671.4	524.6	612.6	2041.4	1.1	659.3	581.9

T.truncat GLOW3 BxTop Hole 3

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	132587	452.8	374.9	443.2	348.6	406	1344.6	1.1	434	363.9

2	170335	522.5	419	521.6	404	459.2	1545.8	1.1	522.7	439.4
3	171134	501.4	437	507.6	420.6	461.9	1507.5	1.1	507.8	454.4
4	172635	502.1	439.5	514.3	411.1	464.3	1524.9	1.1	512.2	441.5
5	183843	520.2	457.5	530.9	418.2	482	1582.1	1.1	535.6	481.3
6	194097	534.3	465.4	547.7	444.1	492.4	1629.9	1.1	509.5	452.3
7	199077	549.2	463.7	551.1	449.3	498.5	1680.1	1.1	552	460.3
8	200115	545.2	470.3	568	431.9	499.3	1682.8	1.1	538.1	481.4
9	204842	539.1	486.9	558.5	464.5	506.2	1680.8	1.1	534.4	480.4
10	205179	559.9	470.1	561.1	438.5	505.5	1708	1.1	540.3	468.9
11	211211	562.1	479.9	558.1	459	513.5	1691	1.1	559.3	473.3
12	226837	575.9	506	603	474.4	532.2	1892.1	1.3	592	511.7
13	226907	568.9	509.9	580.7	489.3	532.6	1726.2	1	550.4	504.2
14	228394	601.1	487	606.6	468.2	532.5	1781.5	1.1	575.7	487.7
15	234118	588.6	510.4	585.9	457	540.9	1807	1.1	585.9	538.5
16	242871	594.2	523.3	599.3	489.3	550.7	1833.1	1.1	587.1	520.6
17	245087	615.2	511.3	631.4	469.3	552.4	1984.2	1.3	629.3	499.9
18	246055	612.3	515.4	628.9	490.2	553.7	1852.6	1.1	615.5	533.4
19	254598	632.3	518.5	638.5	474.1	562.8	1948.7	1.2	630.6	547.2
20	323935	708.5	585.3	711.8	551.7	635.9	2097.2	1.1	704.2	600
21	173589	504.8	440	504.6	420.6	465.5	1547.2	1.1	493.9	442.2
22	225701	590	490.2	596.1	482	529.9	1756.8	1.1	588.8	511.6
23	232126	592.5	502.6	582.7	484.2	537.6	1789.4	1.1	580.2	506.8
24	239757	616.8	498.6	613.1	455.8	545.5	1824.9	1.1	594.1	492.9
25	252998	626.7	517.4	621.8	480.6	561.6	1886	1.1	607.7	515.3

T.truncat GLOW3 BxTop Hole 4

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	146460	469	399.2	464.3	375.5	426.9	1395.9	1.1	456.2	397.2

2	153600	495.9	397.6	496.8	358.7	436.8	1524.2	1.2	518.4	387.9
3	172397	522.9	422.3	512.4	395.4	462.9	1560	1.1	506.2	428.9
4	184124	529.5	445.4	535.9	414.5	479.2	1585.4	1.1	510.7	443.2
5	185036	535.3	445.8	559.1	413.1	479.1	1620.9	1.1	552.8	454.4
6	189076	528.8	458.4	526	428.2	486	1613.2	1.1	512.3	442.8
7	193157	527.8	468.7	526.4	438.4	490.9	1633.8	1.1	522.6	480.3
8	196342	544.4	462	537.1	434.7	494.8	1654.7	1.1	535	468.7
9	202528	544.1	477.2	545.2	444.2	502.4	1682.3	1.1	539.8	483
10	205642	562.1	468.8	559.2	435.2	505.7	1708.4	1.1	549.3	485.4
11	209121	568.3	473.4	577.3	431.2	509.8	1718.7	1.1	556.4	478.6
12	234174	598	503.1	629.7	474.9	540.4	1841.5	1.2	618.6	513.7
13	235085	585.7	512.8	598.4	474.8	542.5	1826.4	1.1	597.7	513.1
14	235815	592.1	511.1	598.7	461.3	542.1	1904.6	1.2	599.1	536.3
15	249309	622	514.7	631.3	473.1	557	1857.7	1.1	628.3	516
16	253405	614	531.3	615.7	503.3	564.3	1891.5	1.1	602.9	531
17	269972	651.3	531.2	653.5	489.3	579.4	2005.8	1.2	647.7	550.6
18	292822	641	584.4	654.5	544	605.7	1982.5	1.1	654.4	602.2
19	315799	703.4	575.5	706.1	540	627.5	2089.6	1.1	697.2	589.7
20	368542	769.4	616	774.2	564.9	678	2326.7	1.2	760.5	636.3
21	116582	411.9	362	430.1	343.8	380.8	1261.9	1.1	395.6	354.2
22	141733	468.6	390.5	477.8	351.1	418.9	1407.7	1.1	466.1	398.8
23	167768	503.5	426.6	499.8	404.7	457	1521.3	1.1	489.6	427.8
24	187743	544.7	443.1	543.9	407.1	482.6	1626.6	1.1	544.3	457.9
25	200227	531.1	483.1	541.3	464.5	499.9	1641.4	1.1	529.7	482.9

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	50119.9	280.5	238.2	277.5	209.9	253.4	847.5	1.1	272.2	237

2	50540.8	283.5	231.6	274	199.4	250.7	840.7	1.1	272.9	225.6
3	53767.1	289.1	246.5	291.4	218.8	261.3	885.8	1.2	278.7	244.1
4	54819.1	290	243.2	284.9	222.5	260.3	853	1.1	279.9	242.9
5	57302	301.2	244.6	298.1	209.7	264.9	894.6	1.1	292.8	243.2
6	57456.3	302.8	248.2	298.7	221.8	266.9	911.7	1.2	292.5	249.7
7	58045.4	301.7	246.4	299.1	225.3	267.2	884.2	1.1	297.6	242.2
8	58283.9	302.3	249.2	295.6	214.3	268.9	904	1.1	289	248.2
9	58311.9	304.9	244.2	297.5	224.1	267.5	878.3	1.1	296.9	240.4
10	58494.3	295.2	253.9	291.7	238.2	268.4	877.3	1	292	257.5
11	58536.4	303.4	250.7	298.2	231.2	270.2	901.2	1.1	296.1	255.7
12	59055.4	303.7	254.8	303.2	237.2	272.8	919.8	1.1	301.9	258.3
13	60626.5	311	249.1	304.6	225.5	273	902	1.1	304	247.3
14	62983.1	309.8	260.6	301.6	233	279.3	914.7	1.1	297.7	254.1
15	63838.7	316	258.6	308.3	223.9	280.4	938.9	1.1	301.2	252.4
16	67135.2	318.7	271.2	310.8	244.5	287.8	964.1	1.1	305.9	270.8
17	67640.2	327.2	265.4	324.1	241.2	288.7	964	1.1	324	261.6
18	70515.8	339.1	274.3	332.8	247.2	299.1	1010	1.2	333.7	279.1
19	70936.6	336.4	270.9	330.4	237.2	295	994.8	1.1	321.7	268.1
20	75158.9	355	272.7	347	221	304.3	1028.8	1.1	339.3	265.4
21	77178.8	346.6	286.5	340.5	256	308.3	1035.1	1.1	334.2	286.2
22	82228.7	362.4	301.2	358.2	282.8	325.3	1095	1.2	350.4	304
23	82873.9	368	296.4	359.6	258	323.8	1090.8	1.1	349.2	286.7
24	88905.7	377	307.2	374	256.4	333.8	1115.8	1.1	364.6	297.5
25	89649.2	386	304.1	377.1	262.2	335.6	1136.6	1.1	373.2	299.9

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	37481.2	238.5	201.3	236.4	177.5	214.2	707.4	1.1	234.7	198.7

2	41871.8	250.3	216.6	246.2	188.3	228.6	756	1.1	247.9	214.3
3	42040.1	249.5	215.4	245.8	194.3	227.2	761	1.1	245.3	222.5
4	46823.5	276.2	219.9	272	191	240.9	795.7	1.1	269.4	218.1
5	46907.7	277.4	222.3	280.3	201.3	242.7	828.8	1.2	276.9	223.7
6	48829.4	273.9	231.4	275.4	217.9	246.7	840.4	1.2	266.9	236.8
7	49278.3	273.1	231	269.2	194.8	245.9	810.1	1.1	264.8	225.4
8	49755.2	280.7	227.3	280.8	207.2	246.5	833.5	1.1	269.3	225.6
9	50330.3	273.4	237.5	271.8	219.8	249.1	823.9	1.1	269.6	244
10	52813.2	287.2	238.4	283.4	213.1	255.5	860.7	1.1	276.7	241.9
11	53149.9	289.6	243.1	293.6	229.7	260.3	866	1.1	293.3	250
12	55450.4	289.5	251.2	288.7	240	264.3	880.9	1.1	283.9	255.8
13	61369.9	312.8	252.5	314.1	235.2	275.2	929.4	1.1	308.6	258.8
14	61622.4	312.6	258.7	308.2	242.9	277.8	930.3	1.1	300.6	258.9
15	62800.7	308.9	261.8	302.1	218.4	279	923.9	1.1	299.9	252.7
16	62941	315.6	258	307.1	228.5	279.9	926.5	1.1	299.7	248.2
17	62969	319.1	260.4	312.2	230	282.1	941.3	1.1	307.3	259.4
18	64441.9	324.1	255	320.5	223.9	281.2	949.4	1.1	311.4	249.3
19	66433.8	331.8	261.1	323.6	226.3	288	964.1	1.1	318.5	255.4
20	66447.8	326.8	260.4	317.8	219.2	285.8	948.7	1.1	312.2	249
21	68004.9	311.6	279.1	308.2	247.6	290.1	953.8	1.1	299.7	277.2
22	72171	344.9	274.6	340.5	242.9	300.5	1015.4	1.1	334	271.8
23	74233.1	340.1	282.5	333.9	249	303.1	1026.6	1.1	324.2	282
24	76210.9	345.4	287.7	342.4	246.9	307.6	1047	1.1	325.2	285.2
25	77992.4	353.4	287.1	346.4	258.5	312.1	1065.8	1.2	344.1	288.7

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	38898	242.7	206.8	239.7	194.8	218.7	730.1	1.1	238.3	208.9

2	40946	246.9	213.7	242	199.1	224.5	747.7	1.1	242.1	214.1
3	41072.3	250.4	209.9	243.1	191.9	224.3	740	1.1	242.7	213.7
4	44102.2	261.2	216.4	253.9	198.3	231.9	767.7	1.1	248.4	214
5	44845.6	264.1	220.5	259.4	204.8	236.3	787.2	1.1	254.6	224.9
6	45028	265.8	216.5	258	199.1	235	769.9	1	254.8	212.1
7	46739.3	268.8	222.4	264.8	194	239.7	787.7	1.1	261.8	217.8
8	47496.8	271.9	223.9	265.5	199.1	241.5	806.6	1.1	264.3	224
9	47931.7	272.4	225.3	266.2	195.4	242.7	809.3	1.1	260.1	220.3
10	50204.1	281.2	229.1	275.4	206.6	247.7	832.2	1.1	275	231.8
11	50526.7	284.9	231.6	275	203.1	251.3	835.4	1.1	270.6	224.5
12	51705	289.3	235.7	281.8	202.3	256.2	848.6	1.1	278.2	225.4
13	52097.8	285.1	233.4	279.1	206	253	827.4	1	277.2	225.1
14	52224.1	289.3	232.5	283.4	206.3	253.7	853.1	1.1	280.9	227.6
15	53598.7	291.2	235.8	287.8	203.5	256.4	855.4	1.1	284.8	234.9
16	54187.9	294	236.6	284.7	218	258	859.1	1.1	284.8	237.8
17	55310.1	297.7	238.8	292.7	221	260.2	870.9	1.1	292.5	238.8
18	56853.1	300.3	245.2	292.5	218.2	265	898.3	1.1	285.4	244.1
19	57316	294.3	249.3	286.8	219.2	265.9	875.2	1.1	280.5	245.6
20	59476.2	300.1	253.5	296.6	232.2	270.6	889.4	1.1	296	252.3
21	61594.4	306.5	261	301.9	225.8	276.7	929.6	1.1	292	259.7
22	64105.3	319.7	257.3	314.1	217.4	281.2	931.5	1.1	311.8	254.4
23	70109	331.4	271.3	323.6	243.5	294.1	986.9	1.1	323.2	266.6
24	76491.5	352.1	280	347.3	243.9	307.2	1044.4	1.1	343.7	273.8
25	93871.4	388.7	311.9	377.7	269.7	341	1153.3	1.1	372.3	310

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
6	45448.8	270	227.7	268.5	200.3	242.8	823.4	1.2	264.6	228.4

26	47328.5	260.7	232.3	259.3	205.7	241.6	788.4	1	258.1	226.1
136	48675.1	274.6	227.5	273.2	197.1	244.3	816	1.1	271.3	226.2
21	53388.3	292.3	234	285.6	210.6	255.7	854.8	1.1	284.4	231.4
25	53444.4	293.3	237.6	288.8	213.5	258.2	860.4	1.1	283.4	235.5
84	58311.9	301.6	249.2	306	223.9	267.9	912.3	1.1	299.6	247.3
133	59911.1	306.8	250.8	298.3	217	271.7	909.9	1.1	296.7	246.5
5	61664.5	313.1	252.3	302.5	209.7	275.3	917.8	1.1	296.7	243.8
55	64245.5	313.2	263.8	311.2	221.8	281.1	942.7	1.1	305.4	260.8
22	64385.8	325.9	256.3	317.4	224.7	282	958.1	1.1	313.2	256.1
4	65353.7	316.1	264.4	309	233.7	284.2	935	1.1	308.1	258.9
92	65802.6	333.9	252.8	322.6	205.7	283.6	957	1.1	318.6	243.7
58	67752.4	327.3	270.6	320.1	236.5	291	989.8	1.2	314.3	273
139	70137.1	325.1	278.1	328.6	256.3	294.7	978.5	1.1	321.8	278.9
135	70964.7	336.4	272.8	327.2	247.2	296.6	996.1	1.1	322	270.2
3	73419.5	349.1	272.4	342.6	225.8	301	1032.4	1.2	332.8	265.6
93	74415.4	340.9	282.1	338	233.3	304.1	1013.7	1.1	329.4	279.6
137	74541.7	335.1	285.7	335.9	260.2	303.4	1017	1.1	326.3	277.5
57	77038.5	350.5	283.4	346.7	241.8	307.9	1044.1	1.1	341.9	284.7
89	79787.9	351.8	291.5	343.8	270.5	313	1050.8	1.1	338	295.7
54	81765.8	360.8	290.5	354	247.2	317.2	1066.1	1.1	349.1	284.9
2	81807.9	363.5	289.6	359.4	243.5	317.2	1070.6	1.1	354.5	288.7
88	84627.4	374.5	291.6	370.9	243.5	323.1	1093.5	1.1	367.7	293.4
53	85132.4	366.7	302.9	361.7	254.7	326.1	1111.1	1.2	356.2	300.2
20	117578	428	358.3	426.5	304.8	383.7	1431.1	1.4	412.6	382.8

M.limbata 872C 4H 2 115-117 Hole 1

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	292135	703.6	531.4	699.2	484.7	601.8	2018.3	1.1	695.1	533.7

2	329251	700.7	600.8	707.7	569.4	642.2	2125.6	1.1	690.3	622.3
3	355511	732.2	620.5	734.7	572.4	667.1	2203.3	1.1	717.7	639.8
4	355960	712.4	640.4	724	583.2	667.7	2207.1	1.1	715.4	663
5	388265	762.1	650.7	773.9	599.5	697.9	2287.9	1.1	761.8	649.9
6	389499	744.3	668.3	745.6	603.8	699.1	2293.5	1.1	736.1	676.8
7	409376	771.9	676.5	769.9	633	716.9	2331.3	1.1	769.3	681.4
8	415997	831.4	641.5	827.9	576.6	719.3	2388.8	1.1	828.5	642.1
9	422506	781.1	690.5	782.8	649	728.5	2381.9	1.1	781.4	709.9
10	477872	860.5	713.6	865	663.9	772.4	2583	1.1	864.5	734.8
11	501634	868.9	740.6	859.4	662.1	792.5	2651.2	1.1	844.2	732.8
12	507007	877.6	740	883.9	679.1	796.3	2639.8	1.1	877.8	737
13	516896	888.2	743.8	887.7	689.1	805	2697	1.1	874.6	738
14	522465	881.1	759.6	883.9	710.3	808.9	2724.6	1.1	873.2	767.9
15	568278	943.9	770.7	956.9	671.3	843.2	2833.1	1.1	956.2	775.1
16	207101	586.8	453	591.2	421.7	506.4	1698.5	1.1	590.2	462.7
17	282961	681.7	533	672.3	477.1	592.6	1992.6	1.1	669.7	538.6
18	307299	698.5	561.6	697.8	510.9	619.6	2040.1	1.1	698.4	554.8
19	342409	753.6	584.5	761.4	546.3	651.4	2192.6	1.1	757.6	603.3
20	353631	734.8	616	721	573.9	665.1	2193.1	1.1	718.4	626.3
21	386694	790.8	627.6	797.8	587.9	694.2	2333.8	1.1	798	644
22	423740	876.6	619.2	881.1	558.7	723.3	2456.1	1.1	878.1	628.9
23	479443	857.9	716.5	861.6	656.8	774.4	2574.8	1.1	870.2	738.2
24	483805	906.9	684.4	892.2	584	774.1	2652.2	1.2	900.8	692.8
25	501775	896	716	890.3	627.8	791.6	2634.4	1.1	890.8	711.8

M.limbata 872C 4H 2 115-117 Hole 2

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	355048	726.2	627.9	726.9	558.8	665.8	2244.9	1.1	727.3	626.7

2	369398	788.2	599	780.1	548.5	678.6	2250.5	1.1	778.7	591
3	417989	814	656.3	819.8	609.8	723	2384.6	1.1	821.8	665.9
4	419111	795.9	672.9	793.9	625.1	724.5	2389.6	1.1	792.9	671.3
5	429533	812.6	676.3	811.9	582.8	732.8	2471.7	1.1	810.7	690.7
6	444739	844.7	676.1	854.6	626.6	744.7	2517.2	1.1	855.9	695.1
7	476146	874.8	698.7	882.2	622	770.6	2604.2	1.1	871.2	725.8
8	557197	892.1	798.3	904.3	723.2	836.9	2792.1	1.1	896.6	797.6
9	569260	922.1	791.9	938.1	738.9	844.5	2914.8	1.2	930.4	798.5
10	605269	952.9	814.4	960.4	769.7	871.3	2893.5	1.1	960.3	828.7
11	615537	943.4	834.1	946.4	767.7	879.6	2885	1.1	946.8	844.3
12	630055	1006.9	808.2	992.3	696.9	884.6	3026.8	1.2	992.6	826.9
13	328129	731.2	575.8	725	513.1	638.9	2139.3	1.1	730.5	569.5
14	352270	796.6	565	806.5	526.1	660.6	2206.6	1.1	807.7	571.9
15	398154	802.1	635.1	808.4	598.4	705.2	2320.8	1.1	809.6	649.9
16	412967	826.4	641	816.2	565	716.4	2402.1	1.1	805.5	631.9
17	435705	808.6	690.4	813.2	627.4	737.9	2470.8	1.1	794.8	704.1
18	505618	906.5	713.3	913	639.5	794.3	2648.9	1.1	913.8	715.9
19	574044	947	773.8	957.1	727.3	848.2	2827.7	1.1	953.5	781.6
20	696713	1035.2	864.5	1032.2	765.8	933.2	3171.9	1.1	1040.5	860.9
21	316571	676.1	601	695.3	541.5	629.2	2117	1.1	690.7	592.7
22	436814	825	677.7	806.9	598.4	738.7	2474	1.1	801.9	668
23	437571	822	682.7	810.4	616.5	739.4	2542.8	1.2	790	680.6
24	476497	867.4	706.2	880.8	641	770.4	2643	1.2	873.5	725.9
25	533743	895.3	763.8	889.7	706.6	817.5	2755.2	1.1	887.2	780.5

M.limbata 872C 4H 2 115-117 Hole 3

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	357881	780.5	586.5	787.5	559.5	667.4	2229.9	1.1	787.9	610.3

2	392136	754.6	670.3	773	591.9	699.8	2374.3	1.1	748.4	657.1
3	404298	808.3	644.9	813.1	562.2	708.7	2493.2	1.2	790.5	647.2
4	423628	806.7	670.6	803.6	627.1	728	2385.5	1.1	803.3	689.9
5	425942	794.8	684.2	798.6	654.6	731.1	2400	1.1	795.8	698.6
6	430613	826.9	665.7	829.7	591.6	733.8	2486.7	1.1	828	682.9
7	443673	785.1	721.3	797	683.8	747	2462.5	1.1	773.5	717
8	447334	830.9	689.4	873.2	648.8	749.3	2685.8	1.3	876.9	711.5
9	520908	920	725.6	921.6	660.1	805.5	2722.7	1.1	908	757.6
10	521511	923.9	725.6	919	655.4	805.7	2724.9	1.1	915.7	735.5
11	537699	919.3	751.1	926.5	659.6	819.6	2792.2	1.2	912	768.4
12	547897	883.7	792.5	906.7	721.4	829.6	2763	1.1	906.5	823.8
13	556509	933.9	765.2	932.8	680.2	833	2827.5	1.1	936	763.2
14	564954	915.9	791.7	919.6	702	840.5	2886.7	1.2	899.3	805.5
15	591957	971.6	780.5	990.6	735.8	860.5	2878.4	1.1	980.4	803
16	257151	679.4	483.9	668.4	449.8	562.9	1893.9	1.1	679	486.3
17	277532	625.3	569.4	635.4	537.6	589	1947.4	1.1	632	593.6
18	294015	664.5	566	659.9	494.9	606.2	2003.1	1.1	643.5	565.9
19	301491	681.8	566	673.3	512.1	613.6	2035.6	1.1	667.5	571.5
20	306303	687.8	570.9	703.2	537.1	618.2	2100.2	1.1	703.4	587.4
21	345790	755.1	587.8	750.7	540.2	655.8	2183.3	1.1	743.4	593.3
22	352355	768.4	589.5	775	551.5	661.1	2255.8	1.1	775.6	615.7
23	365765	711.8	657.7	711	581.5	677	2252.5	1.1	709.1	656.3
24	382135	783.5	627.9	794.9	545.8	689.7	2355.1	1.2	795.6	646
25	510948	889.7	735.1	900.4	688.9	799.6	2630.9	1.1	897.5	751.2

M.limbata 872C 4H 2 115-117 Hole 4

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	383061	782.1	626.1	786.9	570.8	691.4	2286.8	1.1	778.6	630.6

2	384547	754.8	653.8	766.8	610.1	693.5	2311.5	1.1	748.6	684.8
3	398182	762.3	669.6	764	620.9	705.9	2377.1	1.1	768.5	674.3
4	406402	798.6	650.6	801.2	595.6	712.4	2351	1.1	800.9	645
5	407047	758.7	688.9	777.9	634.1	713.9	2369.1	1.1	770.3	724.2
6	407973	770.5	676.4	783.2	621.5	716.3	2427.4	1.1	784	689.7
7	424301	814.7	666.9	829.5	612.1	728.1	2412	1.1	826.1	693.9
8	454755	845	691	846.3	642	753.3	2566.4	1.2	852.2	691.6
9	458626	812.7	722.2	812.4	648	758.5	2508.1	1.1	821.7	725.8
10	489501	876.7	715.9	910.2	650.4	782.6	2691.2	1.2	920.5	730.8
11	540069	911.5	757.5	895.4	691.9	823	2694.5	1.1	888.3	752.9
12	552946	931.4	764.8	939.3	683.6	830.4	2842.3	1.2	933.9	775.6
13	572795	943.3	778.7	941.8	704.5	846.5	2968.7	1.2	920.9	783.3
14	614611	1029	769.4	1041.2	692.5	872.4	3034.9	1.2	1034.3	802.1
15	682111	1035.1	843	1040.8	790.8	924.1	3099.1	1.1	1046.4	858.4
16	264781	675.4	501	672.8	477.4	573.4	1898.7	1.1	669.8	505.3
17	278388	636.5	560.6	652.3	534.2	589.1	1996.5	1.1	653.3	582.6
18	329434	723.1	582.6	722.5	547.5	641.6	2112.4	1.1	705.4	596.2
19	349423	730.6	611.6	731.5	545.8	661.3	2192	1.1	733	613.7
20	358036	745	613.8	754.8	575.4	669.1	2226.3	1.1	754.5	613.4
21	387367	754.7	656.2	759.4	619.3	696.6	2304.4	1.1	746.8	657.6
22	389934	769.8	646.8	765.4	606.5	699.1	2292.8	1.1	756.3	655.8
23	486976	892.1	698.4	897.8	637.1	779.5	2580.9	1.1	892.1	686.3
24	558628	908.8	786.3	926.7	719.1	837.5	2821.9	1.1	917.5	803.3
25	593289	948.9	801.1	931.8	732.9	861.9	2901.9	1.1	941.4	793.8

G.altiapertura.obliquus 872C 11H CC Hole 1

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	54286.1	303.8	237.7	295.3	217.4	262.9	877.3	1.1	295.7	238.8

2	62099.3	311.6	264.8	315.1	253.3	282.5	941.9	1.1	313.9	270.3
3	64189.4	332.1	252.8	321	203.1	282.3	958.8	1.1	314.3	244.1
4	64904.8	312.5	276.3	313.2	246.9	290	952.7	1.1	300.6	271.2
5	69113.1	325.8	271.1	322.6	243.4	291.9	956.4	1.1	318.8	263.7
6	71736.2	347.2	266.9	335.7	224.8	297.2	1007.2	1.1	334.1	264.4
7	72465.6	332.7	281.9	331.8	256.4	298.6	1018.4	1.1	330.4	292.5
8	78385.2	362.2	290.9	362.1	254.7	317.5	1084.7	1.2	359.1	292.8
9	78834	356.2	295.5	356.1	251.6	319.5	1069.4	1.2	353	289.2
10	80054.4	369.8	279	355.5	229.6	313.2	1073.1	1.1	352.1	277.5
11	80896.1	380.1	285.2	368.5	247.2	322	1072.2	1.1	366.5	277.2
12	81429.1	370.1	289.4	365.3	259.4	320.8	1080.4	1.1	365.9	288.9
13	81485.2	354	297.2	347.8	258.5	318.3	1065.6	1.1	339.7	289.7
14	84851.8	361.7	301.7	359.6	268	324.6	1083.6	1.1	354.4	297.8
15	87292.6	382.2	301.4	376.3	246.9	333.4	1134.7	1.2	377.1	297.9
16	88653.2	367	324.2	386.7	293.1	337.9	1165.3	1.2	379	329.3
17	90210.3	383.3	312.7	379.2	282	339.2	1147.1	1.2	370.5	321.5
18	95849.3	406.4	307.7	413.7	251.9	346.1	1201.9	1.2	414.4	315.2
19	109231	431	327.3	421	290.1	368.3	1239.3	1.1	418.3	321.5
20	111827	404	366	410	338.1	378.8	1293.2	1.2	402.6	376.9
21	135505	473.5	375.1	462.5	322.1	413	1410.9	1.2	453.2	371.1
22	147021	499.3	386.7	498.1	349.8	429.4	1501.5	1.2	498.1	405
23	152829	510.7	387.1	503.7	318.4	434.8	1509.1	1.2	501.6	388.9
24	156209	514.1	402.1	512	365.2	446.7	1554.8	1.2	513.9	410.7
25	158019	494.4	409.1	487.8	362.9	443	1485	1.1	487	404

G.altiapertura.obliquus 872C 11H CC Hole 2

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	47945.7	255.1	247.1	264.8	233.6	246.5	818.5	1.1	264.8	252.8

2	50148	279.4	240.4	278.9	221.8	254.1	853.9	1.2	273.5	243.4
3	55660.8	295	244.1	291.5	224.8	262.7	879.1	1.1	285.7	247.2
4	56151.7	287.4	257.4	294.2	244.6	266.5	886.3	1.1	294.9	266.8
5	61019.2	301	265	299.1	247.6	276.2	924.1	1.1	293.1	269.8
6	63221.5	309.3	264.9	306.5	241.5	281.6	917.3	1.1	303.8	260.4
7	64960.9	305.8	273.1	306.7	253.2	283	943.5	1.1	305.8	280.3
8	65550.1	315.7	265.8	310.9	240.2	284.8	936.9	1.1	307	263.4
9	65942.9	323.9	262.9	323.9	242.9	286.7	963.7	1.1	324.5	261.8
10	69042.9	323.8	273.5	323.6	255.3	292.4	961.7	1.1	315.2	274.2
11	71034.8	332.8	279.2	331.6	256.9	300.5	987.4	1.1	331.2	275.1
12	72788.2	333.9	289.7	333.5	271.5	305.4	1015.7	1.1	330.7	291.2
13	75186.9	342.5	283.3	339.4	249.8	306.2	1012.1	1.1	337.6	279.3
14	78553.5	339.7	301.4	344.8	282.4	313.9	1067.5	1.2	342.4	304.7
15	81330.9	349.5	301.1	344.8	278.4	316.5	1070.5	1.1	341.4	311.6
16	82200.6	363.2	295.4	356.1	251	321.7	1076.8	1.1	345.2	290
17	82888	363.7	295.8	362.3	267.6	320.6	1080.8	1.1	357.6	299.5
18	87278.5	376.1	297.6	369.5	252.7	328.1	1109.1	1.1	367.2	291.9
19	89705.3	382.2	307.6	377.2	274.7	333.2	1153.4	1.2	370.7	313.8
20	94250.2	377.7	331.4	383.6	304.9	347	1190.4	1.2	380.6	342.7
21	102049	418.6	315.9	409.7	273.4	354.7	1223.9	1.2	404.9	320
22	132671	466.4	370.8	455.8	319.6	407.7	1392.6	1.2	446.8	368.8
23	135112	472.3	374	473.7	342.1	412.9	1402.8	1.2	470.9	382.9
24	175062	528.8	436.2	538.1	386.4	472.5	1600.7	1.2	528.6	441.6
25	199428	581.8	443.3	564.3	344.6	496	1750.7	1.2	554.9	435.2

G.altiapertura.obliquus 872C 11H CC Hole 3

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	52406.4	293.5	229.7	282.4	206.6	252.7	847.7	1.1	283.7	233.3

2	52883.3	292.8	243.1	294	224.8	260.9	876.6	1.2	288.9	248
3	53262.1	296.9	231.8	289.9	194.8	255.9	860	1.1	287	226
4	53963.5	289.5	254.4	292.8	237.2	267	896.4	1.2	293.9	263.5
5	56628.7	309.5	246.3	305.2	218.8	269	928	1.2	306.2	251.2
6	61229.6	306.3	263.8	311.5	242.6	278.5	950.6	1.2	309.6	268.1
7	62351.8	320.3	257.3	317.3	228.5	281.5	938.6	1.1	318	250.2
8	66195.3	336.8	261.8	331.8	243.9	290.1	984	1.2	325.8	266.7
9	68229.3	332.1	272.2	329.1	242.9	293.2	1000.4	1.2	326.7	279.2
10	69113.1	333.8	271.6	326.2	246.5	295.3	986.4	1.1	320.3	269.5
11	69309.4	326.7	274.4	333.4	248.2	291.6	990.1	1.1	317.7	270.3
12	73966.5	355.5	267.8	341.8	216.7	300.6	1026.3	1.1	337.2	259.5
13	74219	346.9	275.7	340.1	233	303	1008	1.1	338.8	266.4
14	87741.5	367.5	316.7	367.3	299.1	334.7	1131.4	1.2	366.7	332.2
15	88232.4	368.7	318.1	370.4	298.5	337.5	1136.3	1.2	365.9	322
16	89270.4	383.7	307.3	376.3	275	334	1152.9	1.2	370.2	312
17	91360.5	386.1	304.1	377	262.3	335.4	1129.7	1.1	370.5	297.1
18	92174.1	385.9	310.5	376.8	267.2	339.6	1149.7	1.1	371.5	301.2
19	95316.3	397	311.2	388	275.5	344.7	1172.8	1.1	389.5	305.7
20	96438.4	389.8	316.3	381.4	277.1	344.9	1160.1	1.1	377.1	314.8
21	96985.5	392.8	319.9	389.3	280.9	345.6	1180.8	1.1	383.8	329.2
22	97125.8	409.8	309.1	406.2	277.2	348.9	1182.8	1.1	402.4	304.7
23	117241	440.7	348.1	438.2	286.5	384.5	1299.8	1.1	439.4	352.8
24	138970	480.5	376.9	472.8	327.2	415.3	1439.8	1.2	472.4	387.3
25	147779	495.1	396.1	494.7	349.7	434.2	1481.9	1.2	485.7	391.7

G.altiapertura.obliquus 872C 11H CC Hole 4

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
83	48633	286.3	222.9	277.3	187.3	246.9	827.2	1.1	273.3	213.8

46	59153.6	310.2	258	312.2	232.8	275.8	935.4	1.2	315	263.5
104	61482.1	322.6	250.7	320.1	228.5	277.4	946.4	1.2	317.6	256.9
74	62464.1	323.8	254.1	322.1	205.2	279.9	943.6	1.1	313.7	249.7
84	63179.5	326.5	251.6	321	227.5	279.8	947.2	1.1	318.9	254.8
54	69533.9	332.8	281.4	332.8	249.6	299.6	1029.9	1.2	334.4	289.8
56	75832.2	347.3	280.4	340.2	236.1	305.4	1024.6	1.1	331.4	270.6
76	80278.9	370.7	280.4	363	248.3	314.2	1087.2	1.2	353.8	283.6
4	80615.5	363	291.7	360.2	245.3	319.2	1078.9	1.1	357.4	290.7
44	81976.2	366.2	293.2	361.5	259.3	321.4	1070.7	1.1	353.9	288
6	84683.5	368	302.9	364.6	268.9	328.8	1090.8	1.1	362.4	297.3
22	84683.5	368.2	300.1	363.7	270.9	326.9	1101	1.1	363.5	308.4
23	93633	389.8	320.8	391	297.4	346.4	1172.1	1.2	388.3	326.6
2	95330.3	393.8	314.2	382.8	274.3	345.1	1165.7	1.1	376.2	307.9
21	97055.7	400.9	316.2	397.9	292.2	349.4	1168.9	1.1	400.8	320.5
115	97139.8	405.2	320.9	395.5	293.6	353.5	1204.8	1.2	391.9	322.8
48	99019.5	391.8	324.9	390.8	269.7	350.8	1183.2	1.1	383.5	318.8
102	102442	401.2	333.3	393	299.6	359.2	1202.6	1.1	389.6	335.9
5	104252	415.5	336.7	417.4	304.5	369.2	1227.1	1.1	418.9	340.1
17	107534	420.2	339.7	420.8	296.7	369.7	1273.6	1.2	421.8	342
19	115193	422.5	350.9	418.6	305.7	378.7	1265.8	1.1	415.7	350.2
111	122712	448.2	362.3	442.3	307.1	396.5	1344.8	1.2	438.2	358
114	126808	462.4	361.4	448.9	308.6	401.8	1350.7	1.1	443.9	359.7
75	136178	464.6	380.5	462.5	354.7	412.1	1407.9	1.2	452.2	395
3	150837	508.2	389	498.5	362.7	435.8	1502.8	1.2	502.2	397.6

G.subquadratus 872C 11 H CC Hole 1

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	96564.7	367	343.5	375.4	326.6	350.4	1160	1.1	378.5	342.9

2	98781	392.1	327.1	386.7	290.9	351.6	1199.3	1.2	381.8	323
3	108656	412	352.5	415.7	325.8	374.2	1281.1	1.2	412.1	363.6
4	121309	441.6	358.7	431.2	311.7	390.5	1317.8	1.1	420	353.7
5	131269	447.3	384.2	446.6	338.8	406.5	1392.2	1.2	428.4	392.8
6	136136	477.5	369	467.3	293	411.7	1402.2	1.1	463	360.5
7	137399	481.2	371.6	474.1	315.7	413.9	1429.6	1.2	474.6	366.5
8	138338	461.3	393.9	458	338.8	418.1	1433.3	1.2	446.7	397.4
9	138956	491.7	374.2	485.7	338.4	419.9	1452.5	1.2	487	380.5
10	143346	476.8	389.7	476.4	340.1	423	1448.5	1.2	470.6	397.8
11	146811	489.1	389.1	483.3	335.4	426.2	1466.6	1.2	470.8	393.5
12	155255	500.6	412.8	496.3	349.9	448	1528.4	1.2	481	408.9
13	160291	497.7	415.3	495.9	380.1	445.8	1508.6	1.1	491.8	428.8
14	160600	501.4	419.8	495.4	364.9	450.1	1537.5	1.2	482.7	422.5
15	161834	538.9	390.8	533.3	349.9	448.9	1557.5	1.2	534.8	396.6
16	162578	523.6	399	520.9	314.6	447.9	1567.6	1.2	513.9	403.2
17	162746	518.3	415	525.3	382.7	455	1550.7	1.2	521.6	425
18	164836	536.8	399.7	529.3	333.3	452.6	1591.7	1.2	526.5	401.2
19	165930	540.6	403.8	544.4	380.3	457.2	1574.7	1.2	543	418.4
20	173281	525.9	434.1	528.7	379.2	467.6	1617.7	1.2	511	443.8
21	178373	537.3	434.7	529.9	382.8	474.1	1639.9	1.2	517.8	441.1
22	180673	555.2	420.9	547.4	364.9	471	1652	1.2	545.8	439.1
23	189258	550	445.1	550.9	414.4	483.9	1670.2	1.2	554.9	470.1
24	202135	599.7	436.8	581.4	318.4	497.1	1790.8	1.3	573.6	438.3
25	213133	590	467.1	582.9	406.6	514	1768.3	1.2	580.9	479.5

G.subquadratus 872C 11 H CC Hole 2

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	82298.8	368.8	300.7	366.8	274.7	327.3	1109	1.2	368	306.7

2	98093.7	396.9	319.7	395.7	296.3	349.7	1174.1	1.1	397.8	327.1
3	101811	408.7	320.9	404.1	263.9	353.6	1208.6	1.1	393.6	317.1
4	114534	438.8	342	426.4	292.5	379.3	1289.1	1.2	426.2	334.9
5	118602	437.5	352.9	434.2	300.8	386.3	1306	1.1	431.5	355.1
6	119079	447.9	340.8	440.1	304.8	382.7	1293.8	1.1	438.4	341
7	127916	449.4	368.4	451.6	319.8	397	1377.1	1.2	437.8	367.8
8	129150	454.4	365.8	454.4	301.9	400.6	1349	1.1	449.7	372.4
9	132643	461.4	376.4	450.7	314.6	409.3	1386.4	1.2	440.5	371.4
10	132657	463.2	373	454.2	323.9	406.6	1419.8	1.2	443.3	378.3
11	133850	471.2	368.8	467.9	307.1	409.8	1392.5	1.2	464.9	372.1
12	134902	448.8	400.3	448.8	365.3	415.2	1422.3	1.2	445.7	418.6
13	140288	477.5	379	473.8	323.5	415.8	1438.6	1.2	466.7	386.2
14	140400	471.1	382.7	460.9	312.3	417	1413.9	1.1	450.9	372.8
15	142000	464.7	399.6	466.2	362.4	422.3	1444.1	1.2	463	408.2
16	161848	521.4	404.5	516	335	448.8	1567.1	1.2	509	407.2
17	162760	528.4	405.4	515.4	341.5	451.5	1570.9	1.2	506.2	417
18	163251	511.8	418.6	500.7	349.6	455	1567.6	1.2	489.4	405.3
19	165019	537.7	394.8	531.1	314.7	450.7	1560.3	1.2	529.2	394
20	167782	537.5	421.2	528.7	319.4	466.5	1634.5	1.3	516	412.3
21	175118	544.5	419.4	536.1	354.9	469.9	1588.2	1.1	535	415.9
22	182132	539.4	448.3	536.7	382.8	478.2	1686.5	1.2	519.4	469.9
23	190941	555	444.4	546.5	374.6	486.1	1678.8	1.2	532.1	447.5
24	204997	572.7	471.2	576.3	415.1	507.8	1791.6	1.2	570.9	486.8
25	210103	595.6	460.9	599.9	405.9	511.7	1795.6	1.2	597.9	477.4

G.subquadratus 872C 11 H CC Hole 3

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	71932.6	333.7	279.1	333.9	247.9	298.8	1003.8	1.1	332.5	281.5

2	75467.5	343.5	283.9	340.8	258.6	304.1	1036.1	1.1	333.1	290.6
3	87979.9	362.3	328.6	373.5	298.5	337.6	1157.5	1.2	369	344.1
4	95358.3	395.4	311.4	387.4	269.7	343	1164	1.1	379.7	310.2
5	98037.6	395.1	318.2	389.7	265.9	348	1174.5	1.1	387.2	311.9
6	99580.6	404.7	325.4	402.2	275.5	355.4	1235.1	1.2	396.8	323.5
7	110129	435.1	329.9	427.5	275.5	371.4	1261	1.1	423.2	321.1
8	111995	426.8	347.6	424	288.4	378.3	1309.8	1.2	418.2	342.1
9	126135	442.3	368.9	443.3	331.3	394.2	1377.2	1.2	440.6	377.8
10	126331	457.2	361.4	446.6	328.3	397.9	1355.5	1.2	442.2	365.6
11	126724	463.4	365.3	462.1	318.9	403	1397.6	1.2	459.1	366.9
12	129136	461	365.3	458	318.4	402.7	1385	1.2	452.9	357.6
13	132840	468.6	364.9	466.2	318.4	404.3	1388.3	1.2	460.5	369.2
14	133064	463.4	369.4	454.7	311.6	405.9	1373.8	1.1	451.9	370.3
15	136024	466.3	381.2	472.8	367.9	415.2	1388.5	1.1	474.7	391.8
16	140541	490	383.4	492	331.7	423.3	1473.4	1.2	478.9	382.6
17	142154	486.6	382.6	483.3	334.4	423.2	1450	1.2	480.5	386.9
18	143599	487.7	381.9	477.8	328	422.8	1454.3	1.2	471.8	376.5
19	145072	489.6	380.9	480	322.1	422.3	1461.6	1.2	473.8	377.6
20	149238	500.9	394.4	502.9	358.5	434.7	1495.9	1.2	500.1	407.3
21	151145	509.6	390.1	492.5	327.2	436.4	1504.9	1.2	495.1	393.5
22	159674	506.3	413.2	500.7	350.3	448.7	1529.3	1.2	490.2	408.4
23	162746	519.9	403.3	506.3	349.8	449.7	1524.2	1.1	502	400.7
24	167319	527	410.7	517	323.3	455.7	1583.4	1.2	514.2	402.1
25	167333	519.5	428.7	514.5	371.4	462	1600.5	1.2	496.9	440

G.subquadratus 872C 11 H CC Hole 4

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	90126.1	381	307.3	379.1	257.2	335.7	1121.8	1.1	376.9	312.8

2	97771.1	387.7	326.8	391	295.3	348.7	1187.7	1.1	386.8	331.5
3	102863	408.8	333.1	403.8	298.3	360.9	1240.3	1.2	397	337.3
4	115838	436.5	356.9	431.1	310.9	386.9	1330.2	1.2	425	361.4
5	121407	436.7	367.8	438.9	339	392	1346.5	1.2	426.8	381.6
6	123497	448	353.8	441.6	324.7	390.6	1322.4	1.1	441.2	358.8
7	123792	459.3	356.8	450	289.6	396.7	1356.8	1.2	440.5	348.8
8	126808	451.4	368.2	446.7	326.9	400.3	1348.4	1.1	437.1	370.9
9	129557	448.3	380.3	450.3	343.5	405.1	1435.6	1.3	449	386.5
10	131479	472.1	365.3	474.8	343.8	405.8	1402.7	1.2	473.6	377.8
11	132980	441.6	396.9	446.9	362.5	409.6	1415.7	1.2	447.9	405.2
12	134341	487.3	361.6	481.1	312.2	409.9	1424.8	1.2	481.4	359.4
13	137090	490.1	359.6	482.6	319.8	411.6	1405	1.1	484.7	360.4
14	137230	469.4	376.4	468.8	323.5	411.4	1436.5	1.2	462.9	380.8
15	137847	465.7	381.4	469.8	366.8	412.9	1400	1.1	469.8	393
16	138226	470.5	384.4	461.5	332	418.1	1414.5	1.2	453.6	379.8
17	147260	470.7	411.9	470.8	380.3	430.6	1506.2	1.2	466.9	430.1
18	159941	517.8	396.2	512	338.8	444.1	1501.8	1.1	513	405.9
19	160894	520.3	397.6	516.3	340.8	444.9	1530.1	1.2	514.1	403.8
20	175876	539.5	420.5	533.9	344.5	465.2	1611.5	1.2	532.6	424.3
21	185274	569.5	427	557.2	337.1	480.4	1696.3	1.2	550.7	433.7
22	186803	556.8	439.4	551.7	389.5	483.2	1687.6	1.2	545.1	451.6
23	189216	560.1	438.5	553.8	353.3	485.1	1689.1	1.2	547.6	438.4
24	191152	568.8	441.2	565.6	360.8	490.2	1710.1	1.2	559.6	441.2
25	198081	573.2	455	576.5	363.3	498.2	1762.8	1.2	569.6	464.1

G.woodi 1137A 7R CC Hole 4

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	62295.7	315.4	253.5	309.2	232.1	276.7	912.6	1.1	307.5	259.7

2	68201.3	329.3	266.4	327.6	243.9	289.3	965.3	1.1	324.7	270.2
3	73573.8	340.4	277.2	333.4	247.2	301.2	993.6	1.1	325.5	276.7
4	77627.7	346.9	287.4	340.8	261.6	309.2	1027.5	1.1	339.1	294.9
5	79297	357.7	285.8	359.1	263.9	312	1059.2	1.1	357.4	297
6	79759.9	351.7	291.5	353	280.8	313.6	1039.2	1.1	354.6	305.1
7	81611.5	363.1	288.6	363.9	261.9	316.4	1061.1	1.1	360.9	293.9
8	84459	379.6	287	377	251	321.3	1101	1.1	372.4	292.3
9	86871.8	379.2	295.6	372.1	270.9	326.4	1100.7	1.1	372.1	302
10	87054.1	383.1	291.9	371.5	262.2	326.7	1089.7	1.1	370.8	288.4
11	87825.6	371.2	304.6	368.4	283.6	329.2	1099.7	1.1	366.8	312
12	88400.7	378.4	299.5	373.2	283.1	330	1087.6	1.1	372.4	306
13	96536.6	387.1	321.3	395.8	302.5	345.1	1167.7	1.1	396.7	342.3
14	99229.9	392.5	323.5	389.5	283.8	350.6	1159.7	1.1	384.1	324.1
15	102386	389.1	338.3	391.8	310.3	355.8	1196.6	1.1	389	355.1
16	103466	414.3	321.6	409	289.1	356.3	1201.3	1.1	402.2	327.9
17	105514	400.7	338	409	322.6	361.4	1200.3	1.1	406	345.1
18	108558	420.5	331.8	409.6	299.6	365.5	1226.6	1.1	403	336.8
19	114169	433.2	338.8	418	299.6	375.4	1268.6	1.1	424.5	345.6

G.woodi 1137A 7R CC Hole 3

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	83322.8	357.7	299.2	352.6	277.2	320.3	1060.7	1.1	348.3	302.7
2	83757.7	352.4	306.8	356.9	287.2	321.5	1083.4	1.1	357.9	322.5
3	85370.8	379.1	289.9	378.3	271.8	323.1	1096.1	1.1	380.5	303.7
4	87236.5	372.3	302	369.8	276.5	327.7	1094	1.1	369.8	307.9
5	87264.5	380.4	295.8	385.8	281.5	327.6	1124.2	1.2	385.1	313.9
6	90210.3	385.2	300	376.3	273.8	333.2	1106.2	1.1	376.2	301.4
7	92609	391.7	303.1	384.7	270.3	337.8	1125.4	1.1	387.6	309.7

8	95709	393.7	313.9	395	284.4	343	1166.6	1.1	386.6	320.9
9	95849.3	389.1	316.1	386.4	297.5	343.7	1147.1	1.1	388.7	322.6
10	95919.4	393.5	313.1	388.4	283.8	343.4	1154.9	1.1	385.3	318
11	97027.6	398.7	313.2	391.9	286.7	345.7	1169	1.1	383	318
12	98696.9	406.1	313.4	396.4	274.7	347.6	1182.6	1.1	392.3	315.3
13	100282	405.7	317.4	395.9	293.3	350.9	1173.1	1.1	393.9	320.9
14	100591	409.6	314.9	407.7	289.1	351.6	1212.5	1.2	409.5	325.5
15	101951	405.7	323.2	402.9	301.5	354	1188.6	1.1	402	340
16	104196	417.5	320.2	411.4	284.6	357.8	1201.4	1.1	408.3	329.6
17	104855	408.3	331.2	400.1	304.8	359.5	1210.8	1.1	397.8	338.6
18	106959	415.6	331.1	415.8	311.6	363.2	1221.3	1.1	416.8	345.6
19	109175	423.8	331.1	440.6	280.9	366.6	1282.8	1.2	415.8	316.6
20	110382	432.7	329.3	430.5	300.5	367.8	1278.4	1.2	428	354.9
21	113468	428.2	340.5	429.3	316	374	1267	1.1	428	359.6
22	115025	448.5	330.4	428.9	289.3	375.1	1287.6	1.1	427	331.9
23	116484	427.6	351.2	434.2	328.2	379.2	1287.8	1.1	434	374.3
24	135365	463.6	375.3	463.3	346.2	409.6	1372.2	1.1	456.3	383.3
25	136837	474.1	371.2	476.7	317.3	410.9	1418.3	1.2	461.7	368.8

G.woodi 1137A 7R CC Hole 2

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	61299.8	316.8	248.5	312.8	224.7	274	909.4	1.1	306.2	247.6
2	64862.7	307	271.1	305.4	241.1	283.2	935.4	1.1	295.8	269.6
3	68467.8	328.3	267.7	322.2	247.2	289.9	969.8	1.1	323.6	277.1
4	70165.1	350.1	256.3	342.1	232.1	293	971.4	1.1	344.2	251.4
5	72465.6	331.7	281.1	327	261.8	298.7	996.3	1.1	318.2	288.5
6	72563.8	330.1	282.9	325.8	259.4	299.3	990.1	1.1	320.2	286.9
7	74303.2	323.2	295.5	334.8	254.7	303.1	1012.7	1.1	323.5	301.4

8	76042.6	353.5	277.2	357.1	258.4	304.9	1053.6	1.2	356.6	307.8
9	76295.1	346.8	283.5	349.8	259.3	306	1034	1.1	351	287.1
10	80559.4	356.6	290.4	360.7	269.7	314.9	1053.1	1.1	359.5	297.2
11	83645.5	365.8	294.9	371.9	277.7	320.5	1080.2	1.1	370.1	306
12	85118.3	372	293.9	369.5	260	323.4	1087.4	1.1	366.7	298.7
13	88190.3	375.4	301.3	368.4	280.9	329.9	1089.5	1.1	367.3	307.5
14	88737.4	377.8	303.1	370.2	268.5	329.9	1116.6	1.1	369.3	311.9
15	89242.4	386.3	297	380.1	256.7	330.7	1111.8	1.1	374.8	298.2
16	90266.4	375.8	309.3	375.7	290.2	333.2	1118.5	1.1	373	317.3
17	95470.6	386.4	317.2	393.3	304.7	344	1149.1	1.1	394.7	339.9
18	98851.2	393.6	323.8	399.8	295.4	349.4	1181.5	1.1	390.9	331.6
19	102162	410.6	320	405.4	290.9	354.9	1190	1.1	403.2	323.9
20	107871	417.1	332.5	405.5	299.6	364.8	1219.8	1.1	400.6	332.4
21	110017	424.3	333.9	412.6	300.5	367.9	1257.9	1.1	408.4	341.1
22	110255	400.2	354.7	416.5	315.1	369.5	1244.1	1.1	413.7	371.8
23	114015	433.4	339.3	430.5	308.5	374.5	1270.5	1.1	427.6	340.6
24	121590	436.2	358.6	434	327.2	387.5	1302.7	1.1	431.6	365.4
25	125559	456.7	354.2	442.9	313.3	393.6	1339.9	1.1	439.8	365.4

G.woodi 1137A 7R CC Hole 1

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	49039.8	281	225	277.3	202.4	244.7	824.5	1.1	274.7	229.2
2	55773	283.4	252.4	286.2	232.2	262.3	861	1.1	284.7	258.4
3	60780.8	314.2	248.6	313.6	227.4	272.2	915.6	1.1	313.2	258
4	68692.2	335.9	263.1	336.5	246.9	290	976.3	1.1	333.3	267.3
5	69281.4	343.2	259.2	336.5	228.5	291.2	973.7	1.1	330.7	255.3
6	70361.5	342.4	265.1	336.5	242.2	293.2	989.9	1.1	338.2	271
7	73391.4	338.6	278.9	339.7	256.4	300.6	995.3	1.1	335.8	286

8	75285.1	362.6	267.4	349.8	228.5	302.7	1054.8	1.2	350.3	261.8
9	78862.1	342.2	296.8	347	270.5	311.9	1048.2	1.1	348.1	311.1
10	81864	349.3	301.9	356.3	282.4	318	1053.9	1.1	354	310.7
11	84108.4	371	292.1	364.5	256	321.1	1077.3	1.1	359.1	293
12	84669.5	378.3	289	369.7	251.9	322	1095	1.1	367	292.3
13	84823.7	383.3	284.2	383.9	272.4	322.4	1083.6	1.1	384.6	296.1
14	85258.6	360.9	302.8	363.3	280.3	324.6	1073.3	1.1	358.6	312.5
15	85342.8	365.6	300.4	363.3	279.6	324.4	1088.9	1.1	357.9	305.6
16	85384.8	373	294.2	367.9	276.2	324.1	1096	1.1	369.5	305.6
17	85917.9	362.7	304.9	362.8	284.6	325.6	1078.7	1.1	355.7	309.3
18	86521.1	371.5	299.5	370.8	282	326.4	1089.6	1.1	367	309.9
19	90448.7	379.3	306.8	378.4	279.7	333.3	1112.2	1.1	370.2	314.5
20	90617.1	360.4	324.6	371	302	334.8	1191.6	1.2	370.5	362
21	95470.6	388.3	316.4	390	299.6	343.1	1155.4	1.1	391.2	332.6
22	97238	404.6	309.2	396.6	266.9	345.7	1157.9	1.1	391.8	307.3
23	100955	411.5	314.3	413.6	303.9	352.4	1177.8	1.1	415.7	336
24	112935	432.4	335.3	430.7	305.2	372.9	1247.7	1.1	432	337.3
25	113075	438.2	333.6	430.5	294.2	372.1	1273	1.1	416.1	340.7

H.praescitula 1137A 7R CC Hole 1

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	74611.8	344.3	276.9	340.1	264.1	303.4	992.5	1.1	340	280.8
2	80138.6	328.8	311.3	331.8	294.9	315.3	1020.8	1	324.6	311.8
3	83224.6	351.6	303.8	369.8	283.1	320.6	1075.2	1.1	367.3	311.6
4	88022	343.6	327.7	361.3	298.1	330.8	1083.8	1.1	338.5	315.2
5	88190.3	357.9	314.8	362.8	301.9	331	1070.1	1	364.2	327.1
6	89929.7	360.4	319.6	358.5	289.8	333.9	1097.6	1.1	359	321.9
7	91094	360.5	323.5	357.1	303.2	336.3	1108	1.1	356.9	333.4

8	94081.8	367.9	326.3	368.1	317	342.1	1112.8	1	368.5	334.3
9	94895.4	375.5	323.3	371.4	310.9	343.2	1115	1	372.7	325.6
10	95526.7	368.7	331	374.5	301.9	344.8	1117.9	1	360.1	332.1
11	95624.9	358.9	341	374.3	310	344.9	1134.6	1.1	362.1	352.6
12	99622.7	379.9	335.2	378.2	318.1	351.9	1140.8	1	374.6	344.6
13	103831	394.8	336.7	414.4	328.5	358.9	1272.6	1.2	418	349.2
14	104813	413.8	324.1	409.5	305.9	359.5	1184.5	1.1	409.8	329.7
15	106664	378.9	360.6	402.6	321.7	364.5	1210.7	1.1	364.3	356.3
16	107155	404.6	338.7	397.8	310.9	364.3	1216.4	1.1	397.9	343.2
17	109035	404.4	344	407.1	326.7	368.5	1195.6	1	405.3	352.8
18	115951	405.7	365.8	427	335.4	380.4	1302	1.2	418	389.8
19	116273	428.6	348	426.5	324.1	379.1	1263.6	1.1	427.6	363.7
20	118686	403.6	375.6	414.6	349.2	384.7	1249.7	1	410.6	387.2
21	121842	413.8	376.8	423.1	357.4	389.4	1272.6	1.1	420	382.4
22	125139	434.3	368.3	437.6	348.6	394.5	1291.3	1.1	436.4	374.7
23	127972	424.7	386.4	425	339	399	1318.9	1.1	423.1	395.4
24	129683	428	387.5	436.4	353	402.5	1320.7	1.1	430.4	404.3
25	137272	425.8	412.1	436.8	381.4	414.1	1359.2	1.1	433.9	411.9

H.praescitula 1137A 7R CC Hole 2

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	68720.3	318.6	275.7	318.4	265.5	291.6	939.5	1	317.7	282
2	73237.1	321.9	290.8	320.5	273.7	301.3	974.9	1	320.5	296.4
3	78216.8	324.8	308	323.1	288.2	311.5	1007.6	1	320.7	309.8
4	79535.4	327.4	309.8	330.7	288.7	314.5	1012.6	1	327.8	310.9
5	80657.6	360.7	285.4	357.4	277.3	315.8	1030.3	1	356.5	292.7
6	85623.3	360.2	304	362.9	296.7	325.4	1058.3	1	358.8	310.2
7	86465	363.4	304	357.8	288.4	327.2	1064.5	1	359.7	305

8	89901.7	370.5	311.4	364.9	293.2	333.1	1099.9	1.1	364.4	311.4
9	91051.9	359.2	324	357.8	291	336.4	1092.1	1	351.6	315.5
10	92721.2	371.3	318.5	381.9	301.1	339.8	1112.9	1.1	382.4	322.2
11	95596.8	383.7	318.1	385.6	305.6	344.1	1128	1.1	387	321
12	97294.1	387.7	320.8	396.7	310.6	346.9	1136.6	1.1	396.5	333.8
13	98472.4	379	333.2	379.3	311.5	349.4	1149.2	1.1	378.7	345.1
14	102877	398	330.5	407.1	315.8	356.8	1187.3	1.1	403.9	338.2
15	103003	376	349.9	376.9	332.4	358.3	1161.7	1	377.9	356.1
16	106314	404.5	336.1	402.9	318.4	363.2	1189.9	1.1	403.5	342.6
17	108979	396.4	351.5	400.9	326.2	368.1	1216.8	1.1	401.4	361
18	110185	390.2	360.4	391.6	333.7	370.4	1201.9	1	394.2	366.3
19	114885	395.2	371.5	398.9	346.8	378.3	1223.5	1	394.1	381.6
20	121169	430.1	360.1	428.2	338.7	388	1279.3	1.1	427.5	367.6
21	122010	421.2	370.1	429.8	346.2	389.7	1291.3	1.1	419.5	364.9
22	135463	448.3	386.4	452.9	354.9	411	1345.5	1.1	448.5	400.8
23	146923	467	401.7	468.5	389.5	428	1388.3	1	466.5	412.1
24	149602	497.3	385.6	489.3	351.8	429.9	1450.1	1.1	490	399
25	154722	473.1	418.2	479.2	361	439.5	1487.9	1.1	471	431.5

H.praescitula 1137A 7R CC Hole 3

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	69954.7	327.4	272.6	335.4	270.2	294.4	956.8	1	335.3	289.2
2	77319.1	327.3	302.5	330.4	293.8	309.9	1006.6	1	330.3	312.6
3	79086.5	344.5	293.7	339.4	270.1	312.4	1020.3	1	339.9	298
4	80685.7	358.9	287.5	354.5	260	315.5	1038.9	1.1	354.4	288.3
5	84178.5	360.1	299.3	353.3	281.5	322.4	1070.3	1.1	355.2	304.7
6	84515.1	371.4	290.8	375.8	268.1	322.5	1064.4	1.1	376.3	292.2
7	85679.4	363.5	301.7	361.1	290.1	325.2	1066.2	1.1	361.3	314.2

8	86366.8	360.4	306.3	358.5	289.6	327.1	1067.9	1.1	360.2	313.1
9	89635.2	358.5	319.2	354.9	299.6	333.7	1082.6	1	355.8	324.8
10	91963.7	362.2	324.6	364.6	306.7	337.8	1105.2	1.1	364	332.7
11	95835.3	369.6	332.3	372	312	345.1	1154.3	1.1	372.5	358.1
12	98121.7	390.8	321.4	386.4	298.2	348.8	1146.1	1.1	386.1	333.7
13	100100	390.4	327.8	382.8	307.4	352.9	1154.8	1.1	386.4	331.4
14	100927	366	352.8	374.6	332.4	354.4	1148.4	1	371	354.3
15	103073	389.3	339.4	382.3	309.9	357.4	1179.7	1.1	378.5	337.5
16	104364	393.5	340	404.7	324.2	359.9	1184.4	1.1	402.2	348.3
17	104687	373.3	358.4	380.9	324.7	361.2	1176.9	1.1	366.9	346.8
18	109680	381.7	367.4	394.5	331.4	369.8	1227.5	1.1	396.9	381.5
19	110171	383.8	366.5	390.7	350.2	370.6	1214	1.1	390.5	375.1
20	113875	399.2	365.5	412.2	318.2	376.7	1238.8	1.1	384.2	362.7
21	114183	389.7	374.2	400.3	340.2	377.4	1217.8	1	393.6	381.2
22	115768	420.8	352.2	418.2	333.4	379	1242.1	1.1	416.8	368.8
23	121562	422.4	367.8	423.4	333.2	389.3	1262.9	1	408.9	358.8
24	123862	423.6	374.6	438.4	343.5	392.4	1294.9	1.1	439.2	395.8
25	127635	415.1	393.6	428.2	359.6	398.9	1315.6	1.1	403	389.4

H.praescitula 1137A 7R CC Hole 4

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	60724.7	299.3	258.9	296.1	244.5	274.1	883.2	1	296.2	261
2	71020.8	312.6	290.9	316.4	270.2	296.8	972.9	1.1	314	305.7
3	77305.1	341.5	289.4	339.2	269.7	308.8	1005.8	1	339.2	296.7
4	84964	345.6	314.5	347	290.1	325	1061.9	1.1	342	318.7
5	89537	367.9	311.6	369.8	288.5	332.5	1136.8	1.1	370.7	323.2
6	92749.2	366.3	324.1	368.1	313.1	339.5	1109.5	1.1	366.2	335.9
7	93941.6	382	314.5	379.8	304.8	341.2	1115.1	1.1	380.6	323.7

8	96368.3	374.2	329.6	374.7	318.9	345.9	1141.1	1.1	372.5	339.5
9	99131.7	385.9	328.4	394.6	310.3	350.8	1147.9	1.1	392.9	339.5
10	100647	391.9	327.7	394	299.6	353.5	1152.9	1.1	383.1	321.6
11	103592	398.1	332.6	395.9	320	358.5	1169.2	1.1	397.4	340.4
12	103845	396.7	335.2	389.5	311.6	359.1	1173.8	1.1	387.4	342.5
13	103999	405.3	327.8	399	316.5	359.3	1177.8	1.1	397.1	330.8
14	104210	397.3	335.6	398.4	320.2	359.6	1195.1	1.1	397.2	343.6
15	108460	401.9	345.1	399.1	332.9	367.2	1200.8	1.1	399.6	352.6
16	110185	381.6	369	392.5	340.5	370.9	1205.2	1	382.4	359.9
17	112668	410.4	350.9	407.7	336.7	374.1	1219.1	1	407.9	358.2
18	116470	411.2	362.9	407	317.8	380.3	1263.7	1.1	402.7	354.8
19	116708	389.9	382.9	405.1	365.8	381.8	1265.6	1.1	407.2	389.4
20	117059	411.8	363.5	410.3	350.4	381.8	1243.8	1.1	409.5	375.6
21	118125	423.5	357	415.3	327.2	383.1	1260	1.1	417	362.3
22	118265	422	358.7	421.2	340.8	383.3	1254	1.1	421.3	365.5
23	133808	455.5	375.8	461.5	342.8	407.6	1344.3	1.1	456.8	392.7
24	160347	477.7	430.8	485.8	368.3	447.3	1495.9	1.1	485.4	459.9
25	169030	499.1	432.9	501	376.8	459.7	1519.7	1.1	490.3	424.9

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	17632.5	166.9	135.6	168.2	124.5	147.9	480.4	1	168.2	141.6
2	17899	166.6	140	166.2	132.7	148.8	491	1.1	168.2	146.4
3	17983.1	165.4	139.4	165	128.2	149	486	1	164.7	147.6
4	18656.5	166	145.5	163.2	138.2	153.1	493.3	1	163.8	149.4
5	18894.9	169.3	150.8	169.5	114.1	153.5	600.1	1.5	163.4	161.3
6	19147.4	161.3	152.5	161.4	141.3	152.7	502.7	1.1	160	150.7
7	20297.7	178	147.4	176.7	141	159.6	542.5	1.2	178.4	153.4

8	21041.1	184	146.7	181.2	142.4	160.9	527.7	1.1	181	153.8
9	21700.4	178.4	156.9	180.7	137.2	163.4	541.6	1.1	173.8	157.3
10	22934.8	181.1	163.5	184.5	149.2	166.5	560.1	1.1	180.6	164.1
11	24744.4	191.1	166.9	196.4	151.7	173.6	581.3	1.1	198.5	175.8
12	25151.1	204.2	158.1	199.8	151	175.8	590.1	1.1	199.4	165.7
13	25291.4	191.4	170.7	196	158.9	175.7	589.7	1.1	197.2	180
14	26876.5	204.5	168.9	205	145.9	182.1	600.4	1.1	192.7	161.1
15	27255.3	198.1	177.2	197.1	165.6	182.2	606.7	1.1	201.7	176.4
16	28054.8	203.7	177.1	202.7	169	185.9	612.6	1.1	203.2	186
17	28728.1	212	173.5	210.9	164.2	187.2	617.2	1.1	210.7	182.8
18	29513.7	205	185	207.8	174.6	189.8	625	1.1	208.3	188.8
19	30762.1	220.7	179.6	214.9	166.9	193.3	649.7	1.1	216	187
20	30874.3	215.1	184.9	217.2	169.5	193.8	645.5	1.1	215.9	194.5
21	31744	214.5	190.9	218.8	174.8	196.5	655.7	1.1	217	199.7
22	32206.9	219.4	187.8	218.2	179.3	198.7	649.1	1	218.1	193.6
23	32908.3	222.8	190	219.7	180.1	200.3	671.1	1.1	220.7	198
24	34717.8	236.9	188.5	237	179.8	206.2	691.3	1.1	238.9	199.9
25	35517.4	233.8	198.1	233.7	188.2	211	691.1	1.1	235.6	200.8

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	13592.6	143.4	121.6	141	116.2	128.2	421.8	1	138.6	123.6
2	15893.1	157.7	132.6	156.5	126.3	140.6	466.8	1.1	156.3	136
3	16594.4	157.7	135.7	167.5	129.1	142.6	478.2	1.1	167.3	139.4
4	17211.6	154.4	144.9	154.3	130	145.2	497.1	1.1	149.6	148.8
5	18291.7	165.6	142	169.4	132.4	150.7	492.4	1.1	171.8	152.3
6	19554.2	169.6	147.5	169.2	140.2	154.4	511.3	1.1	170.1	150.9
7	20143.4	180	143.2	177	134.5	156.7	512.1	1	177.4	145.2

8	20283.6	168.1	154.7	170	135	158.3	513.5	1	166.5	156.7
9	20522.1	171.7	158.7	176.7	146.3	161.9	530.4	1.1	175.6	166
10	20746.5	170.3	156.7	172.3	147.4	159	524.9	1.1	172.6	161.2
11	21125.3	175.2	156.4	178.1	143.5	160.9	539.5	1.1	180.1	166.2
12	21167.4	178.1	155.7	179.8	138.1	165.3	544.4	1.1	170.6	159.2
13	21223.5	184.9	147.5	184.5	138.2	161.5	534.8	1.1	185.3	155.8
14	21237.5	168.2	162.3	176.1	141.2	161.1	551.4	1.1	183.3	171.1
15	21854.7	176	159.9	176.2	140.2	163.9	550.4	1.1	172.1	159.2
16	22093.2	183	154.8	187.3	146.8	164.8	545.7	1.1	188.5	161.3
17	22359.7	197.6	146.8	218.4	135.7	165	646.8	1.5	217.8	171.9
18	23706.3	186.7	162.8	188.1	143.4	170.7	560.1	1.1	187	156.3
19	23902.7	194.2	159.5	194.8	143	169.9	568.5	1.1	194.2	161
20	25010.9	192.2	168.7	195.7	159.7	175.9	579.6	1.1	195.3	176.4
21	28096.9	216.3	166.4	214.3	160.9	185.5	616.7	1.1	214.1	172.8
22	28854.4	204.3	184.5	207.4	165.9	189.1	640.5	1.1	208.1	195.2
23	29471.6	204.9	184.6	203.9	168.5	190.7	627.3	1.1	207.7	188.2
24	30720	229.6	173.2	228.5	162.6	192	654.4	1.1	230.4	180.7
25	34717.8	238.1	188.2	234.6	178.7	204.6	689.2	1.1	236.7	197.6

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	15921.1	148	138.2	150.2	125.2	139.8	458.7	1.1	150.8	140.9
2	16664.6	163.7	131.2	163.8	122.9	143.6	475.6	1.1	163.5	139.9
3	17478.2	176.2	127.5	189.1	121.9	145.8	530.5	1.3	187.3	134.8
4	19806.7	174.2	146	177	139.2	156.1	516.2	1.1	176.5	154.7
5	19834.8	180.2	143.2	177.7	137.4	156.2	518.2	1.1	177.8	151.2
6	20985	174.9	153.7	177.5	145.7	160.7	524.5	1	177.8	162.1
7	21616.2	183.1	156.6	187.3	147.3	164.9	552.2	1.1	193.2	163.6

8	21658.3	172.4	161.7	172.7	150.7	161.9	541.6	1.1	171.8	169.3
9	22836.6	181.5	161.7	188.1	155.8	166.7	558.6	1.1	189.4	167.3
10	22962.9	181.5	164.8	184.9	145.4	170.9	559.5	1.1	170.2	162.7
11	23089.1	185.2	160.3	187	140.2	167.2	560.1	1.1	187.9	161
12	24029	194.2	159.1	196.6	147.6	171.6	567.2	1.1	197.8	169.1
13	24323.5	190.5	164.2	191	154.4	173.4	570.9	1.1	190.3	172.1
14	24576	186.6	169.5	188.5	162.1	172.7	563.7	1	192.5	175.6
15	24912.7	187.6	172.1	186	160	175.4	578.5	1.1	192.6	175.9
16	25810.4	199.8	165.7	207.8	145.4	178.4	611.8	1.2	210.7	169
17	26175.2	196.4	173.1	198.3	166.9	181.7	591	1.1	198.9	182.3
18	26736.2	209.6	166	217.4	141	179.9	657.6	1.3	216.8	177.2
19	28125	205	178.3	218.8	170.2	186.1	632	1.1	218.5	189.4
20	28840.4	206.5	179.6	211.7	171.2	187.7	617	1.1	213.7	192.2
21	30158.9	216.9	179	213.3	167.5	191.8	638.9	1.1	212.5	186.3
22	33048.6	223.4	191.6	221.3	181	200.8	671.1	1.1	222.4	198.3
23	33918.3	230.4	191.4	233.8	177.5	203.3	756.4	1.3	243	203.6
24	34633.7	226.7	197.8	236.5	175.4	206.3	716.3	1.2	221.8	204.9
25	37102.5	242.7	196.6	243.7	187.7	213.3	708.7	1.1	244.1	204.2

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	15065.4	154.2	130.2	151.7	121.9	137.4	458.1	1.1	154.4	137.7
2	16917.1	154.7	140.4	157.5	133.7	143.5	466.9	1	158.3	141.9
3	18628.4	165.8	145.1	172.3	135.1	150.3	501.6	1.1	163.9	147.3
4	19371.9	165	150.6	165.9	145.7	153.2	504.6	1	167.4	154.7
5	19652.4	176.4	143.5	174.9	132.4	155.2	511.6	1.1	173.2	146.8
6	19736.6	182	141.7	176.7	122.3	155.2	536.9	1.2	178.7	150.1
7	20269.6	181.2	143.4	181.5	140.2	157.8	518.3	1.1	183.7	153.9

8	20900.8	171.4	156.5	167.5	145.4	159.6	523.1	1	168	158.7
9	21363.7	186.3	147.3	186	134.9	160.8	536	1.1	188.3	153.9
10	21532.1	178.6	155.6	178.1	148.5	162.2	538.5	1.1	179.3	162.5
11	22556.1	175.6	166	179.2	146.5	165.8	557.5	1.1	176.1	175.7
12	22682.3	178.1	164.8	177	151	165.7	550.9	1.1	181.6	173.4
13	22710.4	178	165	180.2	153.7	167.3	554.2	1.1	183.7	172.3
14	22976.9	189.7	155.3	185.4	145.7	167.6	544.5	1	184.7	157.5
15	23033	192.1	153.6	192.3	144.6	167	597.5	1.2	193.6	173.4
16	24632.1	187.7	175.2	217.1	153.7	177.6	630.7	1.3	202.5	181.3
17	24884.6	190.8	170.8	189.5	157.9	175.7	584.9	1.1	187.4	172.5
18	25515.9	196.2	169.6	197.7	157.9	177.4	620.2	1.2	200.6	181.2
19	26273.3	196.5	172.7	202.3	157.3	178.5	599.6	1.1	207.2	184.8
20	28223.2	205.1	176.8	206.6	156.8	184.6	627.6	1.1	212.9	175.1
21	28700.1	197.6	187.4	206.4	176.1	186.8	636.7	1.1	208.8	199.9
22	29443.5	228.4	166	232.3	152.8	190	654.7	1.2	236.4	168.3
23	29836.3	211.6	181.2	207.4	154.2	191.1	635.8	1.1	210.5	176.8
24	37986.2	229.7	216.1	234.6	199.5	215.3	736.4	1.1	238.5	231.6
25	39851.9	263.6	195.4	269.9	184.4	219.9	754.7	1.1	267.5	199.9

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	57358.1	309.7	243.8	310	224.8	268.8	912.7	1.2	312.6	260.1
2	68159.2	304.9	289.5	308.5	272.8	289.7	979.2	1.1	310.3	297.8
3	69239.3	323.1	278.9	330.3	255.1	293.1	991.3	1.1	336.3	283
4	69281.4	324.9	283.2	337.6	263.9	296.9	1009.3	1.2	343.8	298.1
5	71076.9	333.8	278	335	263.1	297.7	1010.5	1.1	335.4	300.3
6	75369.3	338.5	286.8	348.3	251	305.1	1021.9	1.1	341.1	302.5
7	78216.8	335.2	311.6	352.1	281.6	318.9	1071.7	1.2	351.7	321.2

8	82691.6	345.5	321.3	355.8	288.8	325.8	1112.6	1.2	358.3	330.2
9	84879.9	365.9	299.5	364.2	278.4	324.5	1089.2	1.1	363.6	312
10	85525.1	362.5	316.8	375.4	303.1	333	1126.1	1.2	382.5	330.5
11	88078.1	361.6	314.7	374.3	292.5	329.8	1116.7	1.1	376.9	326.4
12	92342.4	373.9	319.2	383.3	304.2	339.2	1159.8	1.2	385.4	331
13	93633	381.2	316.6	384.3	295.9	340.2	1135.2	1.1	382.5	322.1
14	94025.7	394.8	308.3	404.2	282.4	340	1173.1	1.2	399.4	321.9
15	94123.9	382	325.3	392	299.3	344.1	1176.4	1.2	395.9	341.4
16	95554.7	382.8	327.7	421.7	258	340.3	1353.3	1.5	370.4	324.4
17	98332.1	392.6	326.6	402	289.7	347.1	1226.2	1.2	404.4	336.5
18	100408	396.5	331.5	398.2	306.5	353	1219.2	1.2	396.9	349
19	102849	401.7	333.1	401	312.8	357.8	1210.4	1.1	406.3	340.2
20	104883	392.7	345.4	398.8	307.2	359.6	1221.1	1.1	392.6	358.9
21	109849	418.2	341.3	427.2	309.4	370.2	1248.8	1.1	427.7	354.5
22	110606	399	358.7	404.8	335.5	369.9	1249.9	1.1	406.9	375.6
23	122726	444.8	355	454.9	332.4	389	1308.8	1.1	457.4	373.4
24	125068	455.9	355.2	472.5	299.2	391.5	1453.3	1.3	465.2	365.5
25	170419	557.1	393.4	557.1	362	457	1575.5	1.2	557.5	419.1

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Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	41310.7	242.7	220.7	246.9	207.7	224.9	759.2	1.1	250.4	229.6
2	41942	243.1	221.9	248.3	207.4	226.8	755.2	1.1	247.6	231.6
3	43709.4	248.4	228.8	257.1	214.5	231.9	796.6	1.2	266	239.2
4	45771.4	262.5	223.7	264.3	200.2	237	791.8	1.1	258.9	232.8
5	46234.3	266.8	227.6	266.5	212.2	239.5	813.3	1.1	266.1	238.2
6	48352.5	264	237.2	269.7	217.2	242.8	826.4	1.1	274.7	247.2
7	49306.3	265.2	240.1	266	222.3	246	829.4	1.1	273.8	243.1

8	51901.4	281.1	239	279.9	226.3	252.3	850.5	1.1	282.4	250
9	52097.8	266.1	253	268.5	236.4	252.6	851.2	1.1	273.1	263.9
10	52210	282.8	243.5	290.9	231.2	257.1	861.5	1.1	290.9	256.1
11	52392.4	278.8	242.7	278.8	230	254.4	842.9	1.1	279.6	255
12	55029.5	290.9	245.4	289.4	227.5	261.1	883	1.1	294.5	255.5
13	56193.8	279	259.8	283.4	235.7	263.2	876.7	1.1	280.9	274.9
14	56684.8	279.2	264.6	278.4	248.3	264	896.7	1.1	293.3	265.3
15	59013.3	294.1	259.5	295.6	242.1	268.8	910.4	1.1	306.7	270.2
16	61496.2	304.5	258.8	312.2	229.6	275.5	919.2	1.1	309.9	271.4
17	63558.2	304.5	280.8	318	260.8	286.8	971	1.2	318.2	297.3
18	65283.6	304.1	277.5	308.5	256.9	283.9	956.2	1.1	314.3	282.1
19	65564.1	302.9	285.9	314.6	271.2	289.2	964.5	1.1	320.3	289.6
20	66307.6	305.8	284.4	307.4	262.2	286	979.7	1.2	320	283.9
21	72563.8	332.8	288.7	337.6	270.6	303	1026.9	1.2	343.3	295.2
22	75271.1	350.3	276.9	345.9	252.9	304	1032	1.1	343.7	291.2
23	89088.1	365.2	313.7	370.3	307.1	332.2	1120.8	1.1	372.6	327.4
24	96326.2	394.4	319.3	398.9	298.2	348.7	1168.8	1.1	402	335.7
25	101727	384.2	342.4	392.1	324.7	354.8	1201.1	1.1	399.5	357

G.decoraperta 872C 9H 2 20-22 Hole 3

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	39487.2	242.6	210.7	246.2	194.8	219.7	738.4	1.1	251.9	218
2	46991.8	261.8	236.3	264.9	225.1	243.4	807.4	1.1	269.6	244.1
3	47567	262.2	234.9	258.6	218.8	242	817.6	1.1	263.7	245.2
4	49292.3	267.8	237	274	219.8	246	819.8	1.1	277.3	247.6
5	52308.2	290.6	236.3	284.6	221.8	255.4	866	1.1	284.2	246.3
6	54468.4	287.8	242.8	292.3	219.8	259.1	855.3	1.1	288.1	244.7
7	55380.2	279.6	259.6	284.6	235.7	263	891.1	1.1	275.2	271.4

8	55660.8	291.5	247.9	292.1	233.3	260.9	889.4	1.1	298.4	254.2
9	57484.3	280.8	265.6	294.5	243.7	266	900.5	1.1	295.7	280.7
10	63081.3	307.8	266.1	313.8	251.1	278.1	943.5	1.1	318.2	276.2
11	63530.1	306.6	268.2	308.5	254.7	279.3	953.9	1.1	308	291.1
12	66546	334.3	255.9	333.4	234.1	285.4	963	1.1	337.4	262.8
13	67051	320.9	273.6	329.3	255.1	289.2	996.7	1.2	333.2	288.5
14	67065.1	326.9	263.9	332.2	243	286.9	985	1.2	330.7	275.4
15	70754.3	329.5	277.5	340.2	264.9	295	1007	1.1	340.2	294
16	71048.8	331.5	278	335	259.6	295.7	1017	1.2	336.3	293
17	71609.9	335.4	276	340.8	255.6	295.9	1025.9	1.2	337.1	288.4
18	76645.8	344.4	287.2	345.3	266	306.9	1035.5	1.1	350.4	297.7
19	81751.7	335.9	316.2	346.7	286.1	317.3	1085.8	1.1	347.5	335.2
20	82649.5	347	308.6	357.7	284.9	318.6	1083.3	1.1	362	322.4
21	89326.6	367.6	318.8	368.8	299.2	334.6	1125.5	1.1	368.8	333.7
22	89438.8	371.3	310.1	380.6	289.8	331.8	1110.9	1.1	382.9	322.8
23	95624.9	367.3	339	377.6	312.3	342.7	1191.3	1.2	382.7	360
24	97378.3	416.6	301.4	430.7	276.2	344.1	1208.7	1.2	433.9	313
25	117508	441.2	346.4	444.6	312.7	379.5	1318.4	1.2	450.3	364.9

G.decoraperta 872C 9H 2 20-22 Hole 4

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	42180.4	252.9	215	256.6	194.8	227.3	761.7	1.1	260.4	218.9
2	49586.9	273.4	233.7	275.5	217.7	246.8	831.1	1.1	277.9	242.9
3	49769.3	272.3	240.7	277.3	211.5	250.5	844.6	1.1	269.7	247.9
4	50863.4	265.5	247.1	267.2	226.4	249.8	832	1.1	260.1	252.6
5	53668.9	284.3	245.4	289.8	234.6	257.8	865.8	1.1	293.9	258
6	54552.6	285.5	247	290.4	233.1	258.6	867.9	1.1	290	265.6
7	54945.4	285.5	248.7	290.7	230.5	259.1	881.6	1.1	293.4	264.9

8	58213.8	282.2	265.9	284.9	251	267.8	889.1	1.1	290.8	276
9	59223.7	293.4	261.3	299.2	243.4	270.9	901.1	1.1	290.1	274.9
10	60121.5	315.2	245.1	317.3	227.5	271.4	913.8	1.1	321.6	254.4
11	60780.8	292.8	268.5	299.9	248.3	273.1	923	1.1	300.6	272.9
12	66658.3	323.1	265.1	321.1	251.4	286.3	954.8	1.1	320.1	283.1
13	67149.2	316.8	278.9	326.3	261.3	291.7	983.7	1.1	330.6	285.1
14	70024.8	323.5	280	325.4	260.9	294.4	988.8	1.1	324.6	296.1
15	72746.2	315	298.1	321.7	270.1	299.7	1006	1.1	314.2	298.2
16	75593.7	337	292.4	344.8	271.4	307	1032.3	1.1	348	299.6
17	76842.2	357.3	282	356.1	261.6	310.6	1040.9	1.1	356.3	286.4
18	84052.2	379.3	283.9	372.7	259.4	321.2	1075.5	1.1	373.3	286.7
19	86086.2	345.2	334.1	357.8	304.6	330.8	1159.8	1.2	362	346.2
20	88036	374.9	301.8	373.1	249.9	329.2	1119.3	1.1	378.9	306.4
21	91570.9	385	305.4	390.7	278.1	335.9	1130.6	1.1	387.6	311.2
22	121085	431.9	359.6	433.5	333.5	387.4	1305.1	1.1	436.8	373.8
23	122642	458.7	353.1	460.4	297.1	392.3	1377.7	1.2	478.1	365.3
24	126724	431.3	383	443.7	345.3	399.5	1366	1.2	441.4	386.2
25	160922	520.7	397.9	533	364.5	445.7	1531.3	1.2	533.8	413.9

G.altipertura.obliquus 872C 5H 5 59-61 Hole 1

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	43975.9	263.7	213.1	263.7	203.1	232.2	761.4	1	265.1	216.4
2	58816.9	289.2	261.2	289.1	247.2	269.8	892.1	1.1	285.3	266.8
3	59279.8	311	243.6	309.9	228.6	269.9	890.7	1.1	308	248.6
4	59321.9	317.8	240	315.2	226.2	270.2	904.6	1.1	315.1	242.7
5	59644.6	290.9	263	287.6	248.9	271.2	891.8	1.1	288.4	271.2
6	61594.4	309.2	255.6	311.5	238.9	275.1	914.8	1.1	304.9	262.5
7	62113.4	297.8	272	304.2	258.9	280.2	929.8	1.1	303.2	280.2

8	62842.8	304.1	265.5	302	250.4	278.1	919.6	1.1	296.1	268.8
9	66195.3	320.5	272.1	318	251.8	290.2	973.8	1.1	317.5	280.9
10	66952.8	322.1	266.3	321.7	252.7	288	952	1.1	319.3	273.9
11	67850.6	325.3	269.7	350.7	255.3	290.2	1054	1.3	350	273.6
12	68439.7	320.2	274.2	318.4	263	291	966.2	1.1	316.6	284.3
13	69926.6	337.3	264.9	325.9	242.8	293.1	970	1.1	323.4	258.4
14	71609.9	322.1	286.1	328.5	272.7	296.9	990.7	1.1	325.7	300.8
15	74948.5	341.6	280	337.1	257.2	304.5	1002	1.1	335.9	286.7
16	76253	336.1	294.8	338.4	274	310.1	1019.8	1.1	331.5	292.7
17	79086.5	331.5	311.1	340.8	291.5	315.7	1061.7	1.1	353.4	316.6
18	79900.1	349.6	293.3	350.3	284.7	314.4	1038.9	1.1	349	304.3
19	81990.2	348.1	304.4	350.6	290.9	319.6	1055.9	1.1	347.6	317.2
20	86114.3	353.3	314	361.7	295	326.2	1112.5	1.1	361.7	335.1
21	91753.3	371.9	318.6	372.3	299.7	338.6	1114.7	1.1	368.2	325.4
22	92090	372.6	322.8	377	308.5	340.6	1138.3	1.1	369.1	326.9
23	93773.2	385.2	313.3	392.5	299.6	341	1138.9	1.1	395.7	328.9
24	105556	402.4	335.6	399.9	313.4	361.5	1228.7	1.1	399.1	339.4
25	124227	431.7	370.7	432.9	349.4	392.6	1304	1.1	438.1	380.7

G.altipertura.obliquus 872C 5H 5 59-61 Hole 2

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	51620.9	284.6	232.8	283.6	210.3	252.8	823.7	1	281.8	227.5
2	56053.5	291.1	246.8	287.1	229.9	262.8	874.8	1.1	281.8	244.6
3	57217.8	300.5	247.9	304.2	235.1	266.9	895.9	1.1	304.6	261.1
4	57498.4	291.8	252.6	292.1	241.7	265.9	878.5	1.1	292.6	260.7
5	58241.8	299.8	254.2	300.5	240.9	271.3	906.9	1.1	297.9	256.2
6	58326	306.8	243.3	298.9	211.4	267.7	884.6	1.1	298.3	234.6
7	62309.8	313.5	254.1	310	233.3	276.9	911.9	1.1	303.5	252.6

8	63011.1	313.2	259.1	308.2	240.2	278	934	1.1	304.1	262.5
9	69155.1	325.1	282.2	325.4	263.9	297.4	988.9	1.1	318.3	285
10	71133	326.6	283.8	334.7	270.3	299.1	1004.4	1.1	329.2	287.6
11	72241.2	343.2	274.1	340.5	244.2	300.3	1020.3	1.1	324.5	267.7
12	73237.1	340.6	276.6	331.3	258	301.3	997	1.1	327.9	280.9
13	74527.6	332.8	292.8	340.2	279.8	306.9	1021.3	1.1	340.2	311.2
14	76000.5	347	282.8	337.4	254.7	307.1	1017.2	1.1	338.6	283.9
15	76870.2	334.8	295.1	332.9	276.5	307.9	1027.5	1.1	333.5	303.7
16	81387	352.7	302.7	358.5	287.2	320.7	1069.5	1.1	358.3	311.9
17	82214.7	348.1	306.6	352.2	290.1	321.8	1060.6	1.1	354.9	307.6
18	83757.7	358.2	300.7	354.1	284.5	322.3	1061.6	1.1	349.8	299.9
19	86885.8	366.8	302.8	365.2	284.6	327.7	1080.3	1.1	365.4	302.1
20	89424.7	364.7	313.8	356.8	299.8	333.1	1092.6	1.1	352.2	318.5
21	93029.8	371.6	333.2	382.3	316.1	347.4	1155.2	1.1	385	345.9
22	97686.9	393.1	318.8	384.6	301	347.6	1151.4	1.1	381.7	320.4
23	103087	399.9	330.3	402.3	315.1	357.2	1180.9	1.1	401.4	341.2
24	113931	419.1	351.2	415.9	333.3	376.7	1269	1.1	413.5	368.1
25	116975	408.9	369.7	420.6	318.9	380.7	1373.7	1.3	413.6	408.9

G.altipertura.obliquus 872C 5H 5 59-61 Hole 3

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	53023.6	273.1	249.2	276.5	240	255.9	836	1	267.7	252.2
2	55955.3	306.3	246.2	310.3	237.2	270	906.6	1.2	312.5	257.3
3	56586.6	296.7	244.7	289.7	226.3	263.7	875.6	1.1	284.7	244
4	59588.4	297	261.2	295.3	240.4	273.9	905.2	1.1	289.1	262.5
5	61524.2	305.4	258.3	301.5	244.9	275.1	914.3	1.1	300.5	264.3
6	62884.9	318.8	255	319.4	240.7	279.2	932.2	1.1	322.1	266.1
7	63474	311.2	263.1	335.9	244.9	279.5	993.8	1.2	335.1	261.8

8	63768.6	315.5	258.2	313	225.5	280.5	916.7	1	309.3	251.8
9	64217.5	321.9	255.7	318.4	243.4	280.7	942.6	1.1	327.2	254.2
10	66588.1	320	271.7	326.2	251.2	288.5	978.4	1.1	319.3	281.1
11	70080.9	323.2	290.8	334.5	277.5	303.8	1012.6	1.2	332.3	300.6
12	71609.9	327.8	281	327.6	256.4	297.6	996.4	1.1	322	292.3
13	76098.7	347.7	286.9	338.7	265.7	309	1037.2	1.1	334.8	285.6
14	77192.8	339.5	292.2	351.8	281.6	308.7	1039.2	1.1	349.1	299.3
15	79689.7	351.1	302.8	349.7	285.8	321.7	1063.4	1.1	349.4	313.6
16	89859.6	365.2	314.5	365.5	298.3	333.9	1092.9	1.1	352	312.4
17	92973.7	379.7	317.7	381.4	299.3	342.3	1126.2	1.1	384.8	322.5
18	96508.6	395.7	319.4	391	299.9	349.1	1159.9	1.1	390	316.2
19	97167.9	387.5	321.9	377.8	299.8	347.2	1156.7	1.1	377.4	325
20	99201.8	383.5	333.1	392.1	315.3	349.9	1177.5	1.1	388.6	346.2
21	103298	389.7	345	393.7	326.3	359.7	1197.5	1.1	394.9	360.9
22	106089	397.9	342	402.8	315.8	362.8	1215.4	1.1	400.4	355.6
23	118167	419.2	365.5	422.7	346.8	385.1	1269.6	1.1	414.7	374.1
24	119359	432.3	354.1	431.3	335.9	384.4	1277.8	1.1	430.1	364.6
25	122964	429.3	368.6	427	346.2	390.1	1306.5	1.1	428	388.7

G.altipertura.obliquus 872C 5H 5 59-61 Hole 4

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	62267.7	302.9	267.9	308.5	254.2	279.7	925.8	1.1	307.7	278.8
2	68902.6	326.3	272.3	326.2	259.8	292.1	970.9	1.1	320.3	277.8
3	69856.5	341.6	269.8	342.3	247.9	298.8	1002.2	1.1	346.3	271.6
4	72311.3	333.2	278.1	327.6	239.7	298.7	992.9	1.1	319.8	269.7
5	75046.6	339.2	295.8	349.8	282.4	310.8	1051.7	1.2	337.3	303.4
6	75271.1	328.3	297.9	360.2	277.5	307.7	1064.5	1.2	358.8	297.4
7	79100.6	347.2	292.6	348.2	273.4	312.7	1043.3	1.1	344.2	301.9

8	80699.7	347.2	304.3	348.2	290	320	1063	1.1	348.3	303.4
9	85118.3	370.4	301.8	369.5	282.8	330.2	1099.1	1.1	364.1	306.8
10	85328.7	362.6	301.5	366.1	281.4	324.4	1078.7	1.1	364.3	318.8
11	86268.6	365.9	313.5	362.7	298.2	334.9	1100	1.1	363	309.7
12	89200.3	360.9	323.5	369.8	308.8	338.4	1109	1.1	365.1	326.8
13	89747.4	377	304.7	375.4	290.1	332.8	1101.2	1.1	375.2	318
14	90196.2	368.4	317.5	370.8	302.3	335.4	1115.9	1.1	366.1	322.3
15	91192.2	375.1	314.3	380.1	299.9	337.9	1130.7	1.1	380.8	334.1
16	95176	373.5	326.7	377.7	311.5	343.2	1132	1.1	374.2	337
17	95204	387.5	328.5	392.8	308.2	354	1162.5	1.1	392.9	336.6
18	96031.7	360.1	344.9	367.3	327	345.7	1147.1	1.1	370	359
19	96719	392.6	325.9	391.6	300.5	350.8	1192.9	1.2	384.9	327.7
20	98963.4	382.6	330.4	385.8	316.6	350.8	1153.9	1.1	381.2	336.5
21	102218	399.2	330.4	415.8	293.7	355.2	1233.5	1.2	394.6	328.1
22	109161	411.4	348.8	413.8	332.5	373.2	1237	1.1	409.7	357.8
23	111308	406.8	353.4	404.2	343.8	373.2	1226.6	1.1	401	364.5
24	119696	425.1	359.9	423.2	342.1	385.7	1263.1	1.1	419.5	363.3
25	126920	442.2	374.2	449.3	355.8	400.9	1348.8	1.1	446.5	389.7

H.praescitula 1137A 5R CC Hole 1

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	78188.8	340.2	294.2	336.9	261.8	311.3	1017.9	1.1	337.8	297
2	81513.3	349.7	297.7	349.7	292.1	317.9	1027.7	1	348.9	305.5
3	91486.8	353.8	330.7	356	318.9	337.5	1094.8	1	355.4	342.2
4	92945.6	371.8	319.7	385.6	308.8	339.9	1105.9	1	384.7	334.6
5	96915.4	388.8	317.9	383.5	311.8	346.6	1118.8	1	383.8	321
6	98360.2	389.6	323.1	389.4	301.2	348.8	1141.9	1.1	383.3	324.7
7	100366	398.2	322	408.3	321	353	1148.7	1	409.5	333.9

8	105542	404.2	333.7	403.1	326.6	361.8	1173.5	1	403.7	338.8
9	106075	372.7	364.1	383.9	343.1	363.7	1172.1	1	378.4	368.1
10	109568	417.1	335.9	415.7	325.6	368.3	1209.9	1.1	417.3	346.9
11	118097	441.3	342	436.1	327.6	381.8	1253.5	1.1	435.7	349.5
12	121744	412.6	378.3	412.4	342.8	388.8	1279	1.1	406.4	383.3
13	126597	420.1	384.9	416.6	370.8	397.6	1278.4	1	418.5	376.4
14	130581	461.9	361.3	456.7	348.3	402.2	1312.3	1	457.6	367.1
15	133836	437.6	391.9	435.8	369.5	408.1	1335.6	1.1	432.9	407.3
16	135617	460.9	375.4	463.5	366.5	410.8	1332.1	1	462.1	380.3
17	142799	464.3	393.5	474	383.2	421.7	1372.7	1.1	471.8	410.4
18	144398	471.2	391.8	473.7	385.5	423.5	1375.8	1	475.4	409
19	152702	485.2	402.6	484.8	382	435.8	1423.3	1.1	481.1	415.9
20	168273	496.5	433.5	489.2	406.6	458.3	1493.4	1.1	489.8	437.8
21	169002	502.7	430.6	497.5	396.8	458.8	1500.3	1.1	497.9	438.7
22	172172	508	432.8	506.2	417.4	463.5	1506.2	1	510.5	436
23	174333	521.3	429.4	516.1	399.6	465.2	1543.5	1.1	514.5	449.1
24	211028	544.9	496.6	572.6	477.8	513.7	1691.3	1.1	575	503.6
25	212094	559.4	485.2	558.8	442	514.6	1693.8	1.1	541.6	469.5

H.praescitula 1137A 5R CC Hole 2

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	44971.9	252.4	227.8	254.9	219.2	235.4	759	1	258	226.5
2	66363.7	343.9	246	338	233.3	285	934.6	1	338.3	242.8
3	67626.1	311.3	277.8	316.5	270.1	289.5	937.8	1	319.1	283.2
4	74148.9	330.4	286.9	327.2	273.2	302.7	987.2	1	327.1	292.5
5	74429.4	329.6	289.6	324.7	274	303.6	1004.1	1.1	325.7	297.1
6	81723.7	349.5	301.8	343.5	269.1	317.1	1065.4	1.1	342.9	312
7	92118	368.1	320.1	366.5	296.1	338.1	1098.4	1	361.9	325.9

8	93464.6	351.5	339.9	356.8	313	341.2	1104.9	1	354.6	349.4
9	95638.9	371.8	328.7	369.7	318.4	344.8	1109.1	1	367.7	337.2
10	99440.3	387.8	328	393.3	319.9	351.1	1142.1	1	393.7	341.6
11	107857	404.2	340.8	401.3	323.9	365.7	1187.5	1	401.2	340.4
12	108825	389.3	357.7	396.4	325	368.1	1196	1	386.1	363.3
13	109989	426.3	329.4	421.7	320.3	368.9	1199.7	1	421.5	335.9
14	110270	415.3	339.3	417.2	323.6	369.6	1209	1.1	419.2	345.6
15	114183	409.1	356.3	412.6	346.9	376.8	1213.2	1	411.4	363.8
16	115165	406.8	362.7	412.4	333.4	378.5	1244.8	1.1	411.2	373.4
17	116007	402.2	368.4	407.7	348.3	380.2	1220.9	1	403	383.9
18	116456	411.7	361.8	406.7	335.4	380.7	1232.7	1	402.5	363.6
19	121870	444.8	350.2	437.3	324.7	388.4	1271.1	1.1	438.7	346.9
20	131086	425	393.6	425.1	373.2	404.7	1309	1	427	391.5
21	142701	446.8	408.8	454.4	360.2	421.8	1378.9	1.1	442.3	411.9
22	164289	485.4	432.3	483.3	404	453.1	1470.9	1	476.1	444.2
23	180379	507	454.9	498.1	412.4	474.7	1544.9	1.1	498	445
24	202500	531.4	487.6	534.7	423.8	503.3	1647.9	1.1	525.4	478.4
25	234146	620	482.8	606.8	456.9	539.4	1782.7	1.1	606.2	492.3

H.praescitula 1137A 5R CC Hole 3

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	68832.5	339.6	258.5	338	256	291	951.6	1	336.3	261.3
2	72872.4	310.7	299.1	317.5	280.7	301	963.3	1	307.9	302.6
3	79395.1	335.4	302.8	334.4	289.6	313.7	1019.9	1	334.9	309
4	84346.8	350.4	307.2	348	299.6	323.8	1040.5	1	346.2	313.9
5	84627.4	351.2	307.8	347.2	287.2	324.2	1056.9	1.1	345.2	308.6
6	85721.5	353.5	309.7	351.2	298.2	326.5	1048.7	1	348.7	311.5
7	87923.8	375.8	299.5	369.6	280.9	329	1089.3	1.1	368.7	307.8

8	95779.2	386.7	316.5	384.2	301.6	344.3	1119.3	1	385.6	323.2
9	99426.3	388.9	326.7	383.6	311.8	351	1136.8	1	379	329.7
10	104981	386.2	347.1	383.9	330.5	361.5	1164.9	1	386.2	345.8
11	107983	405.7	340.4	401	323.3	366.3	1190.6	1	401.9	338.2
12	109835	403.9	347.9	407.7	343.4	369.5	1196	1	408.1	361.8
13	114169	399.2	365.5	414.4	344.8	377	1230.2	1.1	415.5	379
14	116357	411.7	361.4	409.3	335.2	380.6	1242.1	1.1	407	370.3
15	116722	412.2	361.5	417.2	343	381.3	1230.9	1	412.4	372.2
16	123988	410.8	386.5	422.9	353	392.8	1290.8	1.1	408.4	393.8
17	124199	438.1	362	438.4	349.8	393	1277.3	1	438.6	365.1
18	127776	439.4	372.5	446.1	365.5	398.7	1303	1.1	446.5	389.3
19	127958	477.5	342.1	470.3	331.3	396.6	1314.5	1.1	470.7	350.4
20	138998	454	393.2	462.9	367.3	415.3	1370.1	1.1	462.3	411.1
21	149294	471.6	405.6	463.8	372.9	430.7	1418.9	1.1	460.8	417.9
22	157289	503.5	399.3	504.2	384.1	442.1	1443.4	1.1	504.9	404.5
23	158622	463.6	438.9	467.4	417.7	444.9	1451	1.1	469.1	459.9
24	174543	522.2	426.8	528.1	416.9	466.2	1512.4	1	524.2	439.7
25	176731	512.7	441.6	505.6	400.4	468.8	1546	1.1	503.1	447.4

H.praescitula 1137A 5R CC Hole 4

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	72521.7	326.6	283.3	321.9	265.1	300	964.6	1	321.7	281.7
2	76996.5	338.8	289.9	337.6	278.4	309	991.2	1	337.6	293.1
3	79507.4	345.1	294.8	342.5	282	313.4	1018	1	343.8	297.3
4	87334.7	358.5	312.2	356.5	278.4	328.8	1085.3	1.1	357.7	317.9
5	90546.9	365.2	317.3	362.9	301.1	335.3	1089.4	1	364.3	326
6	101671	366.4	354.9	376.4	327	355.8	1155.5	1	377.5	361.8
7	101923	362.8	358.6	375.6	335.9	356.8	1146.2	1	352.1	350.1

8	102709	382.5	343.9	396.3	332.8	357.2	1162.1	1	397.8	362.9
9	103144	395.7	332.7	393.2	318.4	357.8	1156.1	1	391.3	336.9
10	105346	397.9	339.3	404	305.4	361.3	1183.9	1.1	393.1	349.5
11	105669	406.4	332.9	405.4	315.7	361.6	1179.8	1	404.7	346.6
12	106454	400.2	340	397.9	318.9	363.6	1182.3	1	396.1	346.1
13	107983	409	337.1	405.1	319.4	366.2	1186.4	1	403.8	332.9
14	108011	390	354.7	388.6	329.3	366.5	1199.4	1.1	388.6	368
15	108165	372.3	370.6	383.7	349.7	367.4	1173.4	1	375.7	364.2
16	110564	409.4	345.6	401.3	319.4	370.5	1224.1	1.1	399.7	357
17	128982	412	399.7	419.7	375.2	401.4	1297.3	1	412.9	398.3
18	130736	443.5	377.3	442.3	342.5	403	1324.5	1.1	445.1	383.5
19	140653	462.2	388.9	483.3	381.2	418.4	1384.8	1.1	483	390.6
20	141298	470	384.8	474.5	363.8	418.9	1369.6	1.1	473.6	396.8
21	149574	451.9	423.2	462.9	379.8	432.5	1396.1	1	440.1	414.5
22	166562	511.2	416.2	502.8	386.4	455.4	1486	1.1	495.7	425.3
23	180266	517	445.1	523.7	423.8	474.7	1530.5	1	523.4	450.3
24	182202	517.4	450	519.1	428.2	476.8	1569.6	1.1	516.7	477.1
25	212698	540.5	502	542.5	475.9	516.4	1663.3	1	540.9	514.4

G.woodi.apertura 872C 1H CC Hole 1

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	23439.8	195.3	154.3	188.3	141.8	168.7	565.7	1.1	187.9	160.7
2	24323.5	186.9	168.1	188.6	153.6	172.4	578.7	1.1	188.8	178.9
3	24716.3	190.4	167.3	190.3	152.5	173.9	575.3	1.1	187.1	169.9
4	26329.5	205.8	166.1	204.6	146.1	178.9	606.7	1.1	203.4	171.1
5	26876.5	214.9	161	212	149.1	179.5	608.9	1.1	211.2	164.1
6	27129	204.2	171.8	209.4	164.2	182	611.5	1.1	211.5	182.2
7	27535.8	209.4	169.9	211.5	156.4	183.3	620.3	1.1	211.2	179.5

8	27788.3	210.3	170.1	210.9	154.4	184.6	613.3	1.1	209.7	175.8
9	28040.8	210.8	171.4	213	165.8	184.5	620.4	1.1	216.7	181.7
10	30074.8	205.1	189.4	209.8	170.8	191.2	644.3	1.1	209.9	200.7
11	30130.9	213	182.8	211.9	168.3	191.7	640.4	1.1	211.8	194.6
12	30299.2	217.3	179.6	221	173.2	193.1	644.4	1.1	221.4	191.4
13	30327.3	218.7	178.4	221.1	168.5	192.1	640.6	1.1	222.6	187.7
14	30635.9	209.9	188.4	214	170.2	193.4	645.9	1.1	215.7	197
15	31351.3	215.2	187.7	221.3	173.2	194.8	659.8	1.1	223	199
16	31912.4	216.4	190.4	218.2	175.4	197.1	661.8	1.1	214.9	194.7
17	32754	211.5	199.6	214.3	177.7	199.8	668.5	1.1	212.1	195.6
18	33230.9	231.8	185.3	237.3	172.4	200.8	680.1	1.1	238.8	197.2
19	34072.6	228.4	192	237.4	173.1	206.5	688.5	1.1	239	208.4
20	34956.3	227	198.7	233.3	188.9	206.8	689.9	1.1	233.2	208.2
21	37298.9	240	199.7	241.1	191.2	214.2	706.6	1.1	240.2	206.3
22	38421.1	247.1	201.1	250	184.4	216.2	735.4	1.1	252.6	215.6
23	38898	235.5	212.9	243.5	178.7	217.9	736.1	1.1	233	213.8
24	38982.2	244.9	205	247.3	188.1	218.3	738.6	1.1	248	219.6
25	39879.9	242.2	211.9	242.1	200.3	221	741.1	1.1	241.3	218

G.woodi.apertura 872C 1H CC Hole 2

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	22766.5	190.5	154.2	195.7	143.1	167.3	555.9	1.1	195	164.8
2	23131.2	188.7	158.4	183.7	145.9	168.1	560.5	1.1	180	163.2
3	24155.2	198.1	156.7	200.3	138.6	171.7	603.9	1.2	201.2	165.4
4	24169.2	181.5	174.6	187.3	161.6	173.7	577.5	1.1	187.3	182.2
5	24814.5	184.1	173.6	191.7	160	174.6	575.8	1.1	191.9	177.4
6	25291.4	186.1	176.7	192.8	158.9	174.7	600	1.1	197.2	184.6
7	25375.6	188.5	174.1	196.1	157.9	175.7	592.1	1.1	195.4	184.8

8	25572	200.3	163.9	203.8	148.2	177	585.5	1.1	206.4	177.7
9	25936.7	200.4	166.2	203.5	156.8	178.3	588.1	1.1	202.6	176.2
10	26147.1	197.8	174.7	203.9	167.2	182.1	599.7	1.1	204.4	185.3
11	26413.6	197.9	171.5	199.7	160.9	179.4	591.2	1.1	200.3	176.7
12	26427.6	193.5	176.4	198.5	156.3	179.5	597.9	1.1	199.6	186.5
13	26960.7	204.6	169.1	206.1	151.5	183.3	600.9	1.1	205.7	172.3
14	27283.3	199.1	177	210.1	155.8	182.6	614.9	1.1	207.7	189
15	27479.7	200.6	177	206	164.2	182.8	617.3	1.1	206.1	187.3
16	28545.8	215.1	171.1	213.5	160.1	186.6	623.5	1.1	214.3	176.8
17	28742.2	207.7	178.3	208.1	162.8	186	629.3	1.1	207.9	187.1
18	28756.2	205.6	180.4	214.5	162.6	189.1	631	1.1	214.8	193.2
19	29022.7	203.4	184.4	207.7	167.9	188	630.7	1.1	211.2	188.7
20	29191	215.2	174.5	219.8	168.2	188.4	630.9	1.1	219.1	182
21	30215	210	185.7	213.5	169.5	191.3	642.2	1.1	211.2	194.5
22	30257.1	214.2	182.8	218.4	173.1	191	648.5	1.1	218.8	192.2
23	31898.3	212.7	193.4	217.7	176.5	197.1	657.7	1.1	214.2	203.5
24	33932.3	213.2	205.4	215.1	183.9	203.1	678.2	1.1	210.7	209.1
25	34816	224.2	201.3	221.1	182.9	206.6	696.3	1.1	222.2	209.2

G.woodi.apertura 872C 1H CC Hole 3

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	18221.6	184	131	187.3	114.6	150.2	537	1.3	188.6	142.5
2	20045.2	180.6	143.5	184.5	135.7	155.8	539.5	1.2	183.7	153.6
3	21237.5	176.9	156	186.3	137.7	160.4	550.7	1.1	185.1	161.1
4	23888.7	183.8	167.8	186.4	152.5	170.5	566.4	1.1	184.8	176.6
5	24225.3	184.9	168.8	188.3	153.7	171.3	570.5	1.1	191.7	180.7
6	24618.1	191.3	166.1	192.3	156.3	173.7	580.8	1.1	193.3	177.7
7	25151.1	193.1	168	199.1	157.3	175.5	585.7	1.1	198.8	178.8

8	25305.5	197.8	164.6	196	150.7	174.9	589.7	1.1	197.2	167.9
9	25543.9	192.2	171.1	196	159.3	177	581.1	1.1	197	179.4
10	26455.7	206	165.6	208	155.4	179.8	603.7	1.1	209.4	173.1
11	26904.6	200.1	173.5	201.7	161.1	181	602.9	1.1	201.6	182.6
12	26918.6	201.3	172.9	210	161.4	181.3	606.8	1.1	212.2	183.1
13	26932.6	207.1	168.6	208	149.1	181.4	618.1	1.1	208.6	175.6
14	27577.9	209.4	169.3	209.8	160	183.8	612.8	1.1	210	178.1
15	28167	208.6	173.9	214.7	166.2	185.4	619.8	1.1	214.5	183.9
16	28587.9	208.7	176.1	214.9	156.8	187.5	619.6	1.1	214.6	188.4
17	29191	203.9	185.1	210	167.5	189.4	634.5	1.1	215.5	196.8
18	30846.3	215.4	183.7	218.8	162	194.8	639.1	1.1	218.2	193.5
19	31197	221.8	181	222.8	167.7	195.5	655.4	1.1	224.8	193.2
20	31659.9	215.5	189.3	219.8	172.8	197	657.7	1.1	220	203.1
21	32206.9	216.7	191.9	221.3	177.6	197.8	660.2	1.1	223.8	203.1
22	32445.4	226.6	184.5	228.8	170.9	199.3	666.5	1.1	230.6	192.4
23	32894.3	213.9	199	218.4	182.8	199.9	673.7	1.1	218.4	204
24	37172.6	231.5	206.7	239.7	192.8	212.8	712.8	1.1	236.8	213.7
25	43470.9	260.7	215.3	256.2	196	230.2	775.1	1.1	253.6	220.2

G.woodi.apertura 872C 1H CC Hole 4

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	26203.2	199.6	169.5	206.8	154.4	178.5	604.6	1.1	207.3	181.2
2	26371.5	198.2	171.7	199.8	162	179.7	598.8	1.1	206.1	178.5
3	28265.2	206.6	176.4	214.5	169.7	185.2	694.1	1.4	211.7	183.5
4	28770.2	206.3	180	207.4	161.1	188.6	626.6	1.1	208.7	189.5
5	28952.6	216.7	172.4	216.1	160.8	187.9	636.3	1.1	216	177
6	29976.6	205.1	187.5	203	176.5	191.3	627.4	1	201.9	193.6
7	30523.6	210.5	186.4	218	169.6	194	638.3	1.1	220.9	194.8

8	30706	213.5	184	214.5	176.7	194.4	628.9	1	215.3	191.9
9	31800.1	218.8	187.1	221.8	174.3	197	650.3	1.1	219.8	192.4
10	32669.8	221.7	188.6	224.8	180.9	200.1	649.3	1	223	193.7
11	33469.4	217	198.2	221	189.1	202.2	662.8	1	223.4	203.4
12	33707.9	216.5	199.4	222.1	186	203.3	661.9	1	222.4	205.3
13	33862.2	218.8	199.2	221.8	188.1	203.6	672	1.1	221.7	209.4
14	34058.6	227.1	192	233.6	181.8	205.1	691.6	1.1	234.7	203.3
15	34395.2	232.3	189.6	233.3	179.8	205.2	675.5	1.1	233.7	193.3
16	34647.7	246.1	182.3	263.5	169.2	204.5	730.1	1.2	267.2	192.3
17	35040.5	235.3	192.3	267.2	184.3	208.2	764.3	1.3	268	207.2
18	35615.6	238.6	191.8	238.2	182.6	209.1	692.6	1.1	240.5	197.7
19	36204.7	235.4	198.2	235.1	181.2	210.1	700.5	1.1	232.8	205.3
20	36288.9	226.5	207.2	255.1	191.2	210.5	747.9	1.2	255.4	229.2
21	36457.2	305.6	164.3	338.8	176.4	206.5	1010	2.2	401.4	185
22	37663.6	256.8	187.3	255.6	180.7	214.7	708.8	1.1	257.1	197.5
23	38168.6	249.6	197.1	248.2	175.9	216.4	740.7	1.1	243.6	197.7
24	41296.7	243.1	219.5	251.1	204.7	224.5	755.6	1.1	256.7	228.9
25	49755.2	339.6	196.1	370.8	175.9	238.9	1070.9	1.8	367.8	220.4

G.woodi 1137A 5R CC Hole 1

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	52027.7	283.6	235.6	281.5	219.2	253	834.6	1.1	276.8	242.5
2	54061.6	289.7	240	288.8	219.2	257.3	849.7	1.1	286.4	238
3	54496.5	296.4	235.2	290.7	213.7	258.9	848.8	1.1	289.7	237.9
4	57680.7	313.2	236.5	300.1	205.7	265.7	885.1	1.1	297.5	231.1
5	58073.5	309.8	240.2	299.9	209.7	266.5	884.4	1.1	298.3	237.3
6	61047.3	296.7	264.4	297	249	274.5	903.7	1.1	291.9	271
7	61524.2	314	250.9	306.5	221.8	274.9	898.5	1	297.3	241.3

8	63754.6	304.1	270.4	304.8	250.9	280	936.1	1.1	307.1	274
9	73812.2	328.2	288.5	328.5	273	302.1	986.4	1	331	296.1
10	75215	326.9	296.9	324.1	282.5	304.5	1011.8	1.1	319.9	304.2
11	81457.2	356.5	293.8	350.6	279.9	316.6	1048.8	1.1	349.3	299.8
12	82397	359.2	294	354.8	273.7	318.7	1050.8	1.1	352.8	300
13	85034.2	344.3	316.2	349	308.5	324.5	1052.7	1	347.3	322.2
14	86142.3	359.8	307.6	360.8	294.9	326	1079	1.1	362.5	320.5
15	96326.2	382.4	323.9	379.1	294.9	344.9	1139.4	1.1	377.9	329.8
16	97392.3	382.9	326.7	377.6	311.8	347.2	1145.1	1.1	376.7	338.3
17	99636.7	393.8	324.6	387.4	293.8	351	1151.1	1.1	381.2	326.1
18	102442	414.1	316.5	399.1	289.9	355.6	1167.9	1.1	398.3	313
19	103340	387.8	341.4	387.5	313.6	358	1171.9	1.1	371.4	337.4
20	109498	419.8	334.6	418.1	321	367.7	1215.5	1.1	417.2	346.8
21	112710	432.3	333.2	423.8	307.2	373.1	1223.5	1.1	425.4	327.3
22	113005	426.6	339.6	418.1	313.9	374	1235.8	1.1	415.8	340.8
23	113889	422.9	346.3	421.1	327.2	374.9	1253.1	1.1	418.3	352.6
24	115333	422.8	351.3	422.7	333.4	377.6	1247.6	1.1	420.5	357.4
25	119065	436.2	349.2	427.9	320.1	384.1	1255.4	1.1	426.3	347

G.woodi 1137A 5R CC Hole 2

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	41956	253.3	212.9	252.5	195.5	226.4	748.5	1.1	252.6	216.7
2	51115.9	296.6	221.6	290.2	191	249.3	839.4	1.1	285.2	217.4
3	55478.4	294.8	242.1	293.6	224.8	260.9	866.4	1.1	296.4	245.4
4	57105.6	319.4	228.3	313.6	209.8	263.9	882.6	1.1	313.3	230.8
5	61734.6	321.7	246.1	308.5	209.9	274.8	915	1.1	307	239
6	63796.7	315.2	260.5	320	247.6	280.1	933.1	1.1	321.4	273.9
7	64554.1	330.4	250.5	323.9	221	280.8	935.4	1.1	319.3	243.8

8	65858.7	322.1	262.7	323.5	235.1	284.5	942.6	1.1	312.8	255.5
9	66251.5	327.1	260.2	320.7	234.6	285.2	948.6	1.1	315.7	262.7
10	66405.8	322.6	263.2	318.4	247.6	286.6	937	1.1	316.3	267.2
11	68201.3	311.8	280.6	314.4	253.9	290.2	955.9	1.1	302.3	284.2
12	69505.8	329.4	270.1	321.7	243.4	293	956.5	1	316	264.5
13	72100.9	344.3	268.9	339.2	234.6	297.3	990.9	1.1	333.7	266.4
14	73068.8	337.1	278	328.9	256.5	299.7	988.1	1.1	326.9	283.1
15	77557.6	345.5	287.8	340.1	274.7	309.8	1012.5	1.1	332.3	292.5
16	78441.3	361	280.5	348.3	246.5	309.8	1042.9	1.1	345.2	288.6
17	80236.8	359.3	287.2	350.4	243.9	313.9	1054	1.1	345.1	280.8
18	80910.1	355.2	292.8	348.2	260.2	315.9	1043.7	1.1	344.6	299.7
19	83813.8	352.3	305.8	355.5	296.3	322	1057.8	1.1	355.5	310.4
20	92160.1	374.4	315.4	368.4	296.3	337.8	1100.9	1	364.9	315.2
21	97630.8	404.4	310	393.7	268.9	346.7	1155	1.1	394.3	311.4
22	107576	420.7	327	407.2	282.8	364.2	1205.3	1.1	402.6	322.4
23	108320	432.7	323.5	421.9	267.4	364.2	1255.4	1.2	414.6	326.2
24	112668	423.3	340.7	441.9	324.7	373.2	1252.8	1.1	437.8	348.5
25	113257	423.5	342.6	420.1	333.4	374.5	1228.3	1.1	422.4	355.5

G.woodi 1137A 5R CC Hole 3

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	42334.7	244.9	221.8	245.5	206.6	227.8	748.2	1.1	246.4	227.8
2	45294.5	251.5	231.2	249	222.8	236.3	768.9	1	248.8	236.8
3	50653	286.1	227.8	283.8	202.8	248.9	834.6	1.1	279.2	227.3
4	53991.5	292	237.2	284.5	213.8	257.2	850	1.1	281.6	237.9
5	60444.1	319.1	243	311.8	206.4	271.9	906.9	1.1	311.4	238.6
6	60696.6	314.5	247.2	310	215.1	272.6	897.4	1.1	307.8	243.3
7	65914.8	317.7	265.9	318.1	254.5	285.3	933.4	1.1	315	271.3

8	67948.8	317.2	275.7	318.6	259.7	289.2	960.9	1.1	318.2	284.9
9	71848.4	330.2	279.4	328.2	260	297.8	977.5	1.1	325	286.3
10	71946.6	349	264.3	335.7	225.8	296.4	982.9	1.1	332.6	256.7
11	73489.6	352.2	267.5	346.6	246.5	300.2	1004.2	1.1	347.4	278.4
12	75621.8	347.6	278.8	343.5	246.9	304.9	1007.7	1.1	338.3	274
13	77066.6	344.6	285.8	343	267.4	308.6	1003	1	337	281.4
14	78749.9	344.1	292.6	335.7	270.6	312.4	1019.9	1.1	333.5	293.7
15	80882.1	347.5	298.1	343.5	286.5	316.5	1035.6	1.1	343.8	300.2
16	83883.9	361.3	297.6	353.6	277.3	322	1051.6	1	350.9	303
17	85048.2	368.9	296.1	361	267.4	324	1070.7	1.1	353	299.4
18	86591.2	370.5	300	361.7	278.4	326.9	1081.3	1.1	357.5	304.2
19	87601.2	362	310.2	355.4	295.6	329.4	1074.8	1	354.1	316.6
20	89410.7	372.1	308.4	368.9	288.2	332.5	1095.3	1.1	366.4	314.2
21	96831.2	374.7	331.6	382.8	322.3	346.3	1141	1.1	385.3	344
22	100128	398.7	321.8	386.7	293.6	352.2	1155.7	1.1	382.8	325.5
23	116694	428.2	348.5	425	327.2	380.3	1235.6	1	423.2	346.1
24	125784	453.8	354.8	449.6	335.7	394.7	1302.8	1.1	449.6	364.5
25	150163	481	399.6	477	371.4	431.9	1430.6	1.1	470.4	401.9

G.woodi 1137A 5R CC Hole 4

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	38827.9	239.1	208.9	235.7	198.2	217.9	720.4	1.1	232.7	210.7
2	47146.1	275.9	219.7	271.3	206	239.8	792.8	1.1	270.6	222.1
3	56263.9	303.9	237.6	298.2	218.8	262.6	877.5	1.1	294.2	243
4	58297.9	295.9	253.3	296.6	239.7	268.1	882.9	1.1	291.5	261.2
5	60570.4	312.9	248.6	304.9	228.5	272.3	899.8	1.1	303.3	250.8
6	62183.5	299.5	266.5	298.9	246.4	277	909.8	1.1	295.2	273.7
7	62604.3	317.5	252.4	310.9	229.2	277.6	919.1	1.1	303.1	256.3

8	63768.6	327.7	249.3	316.4	213.8	279.5	924.8	1.1	314	240.5
9	65017	322.2	260.4	314.1	236.5	281.9	944.5	1.1	310.3	266.6
10	66251.5	333.5	254.8	323.2	213.5	285	954.3	1.1	314.9	248.2
11	68341.5	341.4	257.9	331.8	217.1	288.6	974.1	1.1	328.3	258.3
12	68790.4	325.9	269.9	320	247.6	291.5	946.6	1	314.9	263.4
13	69744.3	342.5	261.8	333.5	237.4	291.6	980.5	1.1	333.9	266.1
14	74597.8	363.3	263.3	357.8	225.2	301.5	1012.1	1.1	357.1	264.1
15	77459.4	344.4	288.2	341.2	273.4	309.2	1005.2	1	341.7	293.7
16	79002.4	358.2	282.9	348.5	262.2	311.9	1042.3	1.1	345.1	288.9
17	91262.3	378.7	308.8	370.9	289.9	336.2	1096	1	369.4	313.4
18	98093.7	392	320.7	391	308.2	348.1	1145.2	1.1	389.7	332.5
19	101741	391.1	333.5	388.5	319.2	355.2	1158.4	1	384.1	342.4
20	104715	396.9	337.9	402.9	329.7	360.4	1188.6	1.1	404.2	355.1
21	108053	412.8	334.8	405.1	316.4	365.7	1204.1	1.1	404.7	342.3
22	126710	437.9	371	441.3	344.8	397.1	1313.8	1.1	443.3	379.7
23	126962	439.8	370.3	434.4	352.1	397.2	1303.7	1.1	431.3	373.8
24	138871	465.4	384	464.3	349.9	414.8	1382.2	1.1	457.8	382.4
25	139839	464.3	385.2	456.9	359.6	416.5	1367.1	1.1	454.8	388.7

G.woodi 1137A 9R CC Hole 1

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	34535.5	228.6	194.1	226.3	180	205.7	674.8	1	221.1	195.5
2	37481.2	231	207.3	232.9	195.3	214.7	691.3	1	231.4	205.9
3	41268.6	253.1	209.6	249	194.8	224.7	739.9	1.1	247.1	206.6
4	43106.2	258.1	213.7	251.4	201.3	230.8	749	1	248.5	216
5	44621.2	261.8	220.2	262.2	204.9	233.1	780.9	1.1	263.5	224.6
6	44649.3	264.7	217.1	258	191.9	233.8	780.6	1.1	251.5	220.9
7	47090	273.2	221	268	203.5	240.1	790.9	1.1	265.9	223.3

8	49250.2	276.9	228.4	276.3	206.4	245.6	815.4	1.1	273.6	234
9	49629	267.9	237.7	267.1	217.1	246.9	809.5	1.1	265.7	237.8
10	50442.6	274	235.4	270.3	221.1	249.1	808.8	1	266.8	234.6
11	51326.3	276.9	237.3	274.3	226.7	251.1	822.7	1	279.9	244.5
12	51887.4	287.6	231.6	289.3	217	251.9	835.7	1.1	287.9	234.6
13	52869.3	289.6	234.4	283.5	217.2	254.4	840	1.1	278.8	234.4
14	55773	300.7	237.7	290.2	209.7	261.5	870.3	1.1	281.3	228.6
15	58466.2	303.6	247	302.5	220.4	268	886.1	1.1	299.1	253.5
16	60261.8	313.6	247	311.7	234.5	271.4	905	1.1	313.3	257.2
17	60682.6	314.9	246.2	312.7	222.6	273	899.4	1.1	312	247.5
18	61131.5	311.6	251.9	308.8	229.6	274.1	905.4	1.1	307.8	255.6
19	61412	310.4	253	310.9	233.3	274.9	901.2	1.1	308.5	255.6
20	62997.1	312.6	257.7	313.1	246.3	278.6	916.3	1.1	312.1	265.5
21	63067.2	316	256.2	311.6	241.6	278.3	925.2	1.1	307.9	260.8
22	65465.9	320.7	262.3	321.3	239.3	283.7	974	1.2	309	259.7
23	66363.7	331.7	255.7	327.2	235.8	285.3	940.4	1.1	325.9	257.2
24	67205.3	327.6	262.6	320.5	226.7	287.7	946.6	1.1	315.4	257.2
25	83505.2	328.9	325.6	335.1	307.7	321.7	1044.6	1	329	325.8

G.woodi 1137A 9R CC Hole 2

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	39515.2	250.7	201.7	245.3	189.5	219.8	719.4	1	247.6	205.4
2	42208.5	256.5	211.1	248.3	194.6	227.1	744.4	1	251.1	206.1
3	43176.4	255.7	215.6	251.8	194.8	230.4	749	1	249.3	213.6
4	44410.8	258.9	220.1	253.5	200.5	233.1	762.4	1	247.6	219.1
5	45645.2	266.2	219.8	264.9	203.5	236.4	778	1.1	262.5	218.3
6	45757.4	269.7	218	267	191	236.4	784.1	1.1	264.1	215.5
7	45995.9	274.7	215	268.1	188.3	236.7	784.7	1.1	264.6	209

8	50695.1	277.8	233.2	272.7	209.6	250	810.6	1	270.8	224.2
9	51452.5	286.7	229.7	284.5	202.3	251	831	1.1	279.8	226.5
10	52111.8	285.5	233.9	280.9	219.8	252.8	832.5	1.1	279.1	238.1
11	52785.1	280.7	243.7	294	222.8	254.3	881.9	1.2	281.8	237.4
12	52967.5	297.1	229.2	293	198.5	253.9	848.1	1.1	288.8	227.6
13	53248.1	290.8	235.8	284.5	210.6	255.2	849.9	1.1	283.2	244.7
14	53486.5	281.8	243.8	278.8	232.1	256.4	842.8	1.1	281	251.2
15	53682.9	278.5	246.8	277.5	232.1	257.1	837.6	1	276.3	253.8
16	54706.9	286	245.1	280.9	231.2	259.5	851.3	1.1	277.5	251.9
17	55141.8	289.1	243.6	283.6	228.5	260.6	845.5	1	282.5	244.1
18	55296.1	295.4	239.7	288	213.7	261	855.2	1.1	284.5	234.1
19	55871.2	290.1	246.7	288	231.4	262.1	855.9	1	287.7	249
20	63249.6	307.5	264.2	308.5	251	279.3	916.7	1.1	306.8	266.5
21	63628.3	318.7	256.7	317.9	246.7	279.3	932.7	1.1	320.2	263.8
22	64161.4	316.8	259.3	315.8	236.7	281.2	918.8	1	310.5	256.2
23	69547.9	331.8	269.4	329	251.1	291.9	974.1	1.1	329.5	278.2
24	71161.1	341.7	267.6	336.7	244.6	295.3	983.4	1.1	334.4	269.4
25	83056.3	366	291.1	356.9	259.4	319.5	1060.3	1.1	349.6	294.1

G.woodi 1137A 9R CC Hole 3

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
5	23958.8	191.4	160.4	185	146.8	170.3	560.4	1	180	157.5
20	37916.1	249.7	194.9	244.8	169.2	214.7	710.5	1.1	241	190.2
3	41942	252.7	212.8	248.3	194.8	226.4	742.9	1	244.8	211.4
21	44088.2	255.5	220.4	256.4	210.3	233.1	754.7	1	255	222
22	45855.6	259.7	227.5	261.6	216.1	237	781.5	1.1	264	233.1
43	46023.9	266	222.3	266	212.8	237.7	779.9	1.1	265.6	225.4
6	46332.5	261.1	226.7	263	206.8	239	773.5	1	260.5	232.5

41	47146.1	280	216	280.3	189.6	239.9	796.9	1.1	279.3	220.2
19	48015.8	266.4	231.5	263.7	214.5	242.8	797.8	1.1	257.5	232.1
1	49292.3	278.6	227.5	278.4	210.9	245.9	813.2	1.1	276.7	226.1
32	51677	279.2	237	275.3	220.4	252.2	823.5	1	270.7	236
38	51761.1	286.6	231	281.5	210.9	251.7	823.5	1	281.5	234.1
4	54875.2	292.6	241.4	287.2	226.3	259.4	868.5	1.1	283	243.9
11	55324.1	288.8	245.2	285.6	229.6	261	855.1	1.1	279.9	250
31	57554.5	296.7	248.4	295.6	221.1	266.1	870.7	1	295.1	253.2
13	58031.4	305.1	244.1	302	232.2	266.4	885.1	1.1	306.1	253.4
12	58199.7	308	243.8	299.6	217	266.6	903.9	1.1	295	252
30	58788.9	290.7	259	291.5	239.5	269.9	881.4	1.1	288.3	262.8
39	59251.8	303.9	250.3	301.1	231.6	270.1	887.2	1.1	298.3	249
42	59574.4	293.1	260.3	290.9	240.8	271	882	1	288.2	262.3
9	60893	300.5	260.6	298.2	242.9	273.7	906.9	1.1	299.4	269.2
10	60907	301.2	258.8	297.8	244.9	273.9	893.8	1	294.3	262.8
33	61299.8	306.4	257	303.5	238.2	274.4	908.4	1.1	301	261.4
16	72662	318	292.5	320	271.3	300.3	972.1	1	312.8	289.9
28	94236.1	362.2	333.7	367.3	305	342	1118.6	1.1	362.8	344.3

G.woodi 1137A 9R CC Hole 4

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	37733.7	233.8	206	233.2	194	215.4	692.2	1	230.3	204.2
2	38000.3	238.6	203.9	233.7	192.3	215.6	702.4	1	229.5	206.5
3	41563.2	255.8	207.5	248.9	183.7	225.5	738.5	1	244.6	204.5
4	42026.1	255.1	210.5	253.3	198.5	226.9	735.5	1	251.4	213.2
5	42713.5	251	218.2	245.4	199.1	228.9	748.3	1	245.3	221.7
6	43990	256	221.1	255.7	206	232.2	766.6	1.1	254.8	221.3
7	45140.2	260.3	222.3	256.9	210	236.5	765.1	1	253.2	224.3

8	46444.8	262.1	227	260.8	210.9	239	784.1	1.1	258.9	228.7
9	47749.3	280.6	218.7	276.9	195.3	241.1	802.9	1.1	276.7	217
10	48661.1	285	219.8	278.3	183.5	242.9	818.9	1.1	275.3	215.7
11	48927.6	279.2	223.9	271	202.2	245.2	800.2	1	272	220.8
12	49166.1	272.9	230.3	267.1	216.7	245.5	799.7	1	262.4	229.2
13	49516.8	269.4	235.2	268.5	225.9	247	801.5	1	268.2	235.9
14	50190.1	284.5	226.2	281.5	205	247.9	817.7	1.1	280.4	225.4
15	51340.3	279.9	234.9	275.3	219	251.5	816.1	1	274.4	234.9
16	51508.7	274.4	240.6	271	224.5	252	824.1	1	271.2	246.8
17	52560.7	294.9	228.8	289.6	209.7	253	842.6	1.1	289.8	227.7
18	53009.6	277.3	244.9	274.7	226.1	255.6	832.1	1	273.6	242.7
19	53388.3	292.1	234.4	290.2	220.4	255.8	843	1.1	293.1	241.6
20	55646.7	305.8	233.8	302.7	217.2	260.4	871.8	1.1	304.5	246.5
21	56039.5	296.7	241.8	296.9	225.3	262.4	858.5	1	295.3	242.2
22	56558.5	290.6	249.4	287.2	214.5	263.4	868.7	1.1	284.9	247.6
23	57330	300.5	244.2	297.8	224.4	265.6	868.7	1	296.8	243
24	57891.1	306.6	242.4	304.4	227.4	266	879.7	1.1	305.7	247.7
25	58704.7	297.5	252.1	291.7	237.2	268.9	872.3	1	289	252.3

G.woodi 1137A 4R CC Hole 1

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	12863.1	134.1	123.2	132.7	113.9	124.1	408.2	1	130.1	124.4
2	17015.3	154.6	141.7	151	134.3	143.8	468.7	1	150.4	142.5
3	17141.5	165.6	132.8	161.1	121.3	144	465.3	1	162.6	133.4
4	17548.3	159.8	141.1	162.1	132.4	146.1	476.4	1	164.4	143.1
5	17927	161.1	143.3	159.1	131.5	148	489.9	1.1	154.2	146
6	17983.1	170.2	135.1	168.2	124.1	148.1	481.4	1	164.8	134.9
7	18137.4	172.2	134.9	166.3	125.6	149.8	488.4	1	168.6	135.6

8	19329.8	173.6	142.8	172.5	133.7	154	500.6	1	173.5	140.5
9	20185.4	175.3	147.6	172.5	134.3	156.7	517.2	1.1	168.5	146.1
10	20199.5	180.2	143.8	176.7	131.1	157.1	513.7	1	176.8	146.7
11	20367.8	166.7	157.4	164.2	149.9	157.3	513	1	167.6	158.1
12	20423.9	179.1	146.8	175.5	127.3	157.7	521.9	1.1	173.3	145.3
13	20452	178.3	147.2	174.9	137.7	157.9	518.4	1	173.6	151
14	20971	182.9	146.8	177.5	130.7	160.9	521.5	1	175.9	142.4
15	21069.2	182.3	148.8	176.1	134.9	160.6	528.5	1.1	176.6	149.9
16	21335.7	174.7	156.9	173.5	144.7	160.8	525.3	1	177.2	161.1
17	21630.3	184	150.8	183.6	142.3	162.9	529.7	1	183.6	153.5
18	21995	193.3	146.1	193.3	134.8	164.5	543.6	1.1	191.7	150.4
19	22317.6	184.9	154.8	184.5	143.9	165.9	541.5	1	181.6	157.9
20	22401.8	192.2	149.5	183.9	135.7	165.4	544.4	1.1	183.5	152.5
21	26203.2	199.3	168.7	199.9	154.4	179.3	589.7	1.1	197.7	174.1
22	26329.5	206	163.8	202.6	151.7	180.4	589.6	1.1	203.1	166.9
23	26329.5	201.3	167.8	199.1	151.8	178.1	586.3	1	194.9	165.3
24	27521.8	212.6	166.6	213.2	149.9	183.3	612.2	1.1	213.7	176.3
25	32010.6	225.8	181.7	226.7	172.3	197.5	651.4	1.1	228.5	186.4

G.woodi 1137A 4R CC Hole 2

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	10885.3	124	113.5	124.5	105.7	113.5	378.7	1	125.1	113.7
2	12807	138.2	119.7	133	110.2	123.5	411.3	1.1	133.1	120.2
3	14013.4	143.2	125.5	142.6	118.3	130.2	422.8	1	144	129.9
4	15640.6	159.9	125.2	153.7	113.7	139	449.9	1	154	124
5	15879	166	123.7	161.4	113.2	140	466.6	1.1	162.4	125.9
6	16117.5	152.2	136.6	150.7	128.1	139.7	462.1	1.1	149.2	139.6
7	17548.3	163.3	138.1	160.3	125.6	145.1	484.8	1.1	159.8	142.7

8	17786.8	162.5	140.7	158.7	129.4	147	484.3	1	157.2	144.4
9	18053.3	158.8	146	154.4	130	147.7	483.1	1	157.3	144.7
10	18319.8	159.5	148	160	137.4	149.4	493.2	1.1	165	152.7
11	18993.1	170.1	143	168.9	134.3	152.4	497.3	1	167.1	145.9
12	19091.3	172.6	141.9	167.4	126.3	153.1	499	1	166.4	141.2
13	19498.1	174	143.7	175.6	132.4	154.5	504.3	1	172.3	146.1
14	19989.1	175.1	147	176.1	137.4	155.5	514.4	1.1	176.4	152.8
15	20213.5	187	138.1	185.5	127.3	159.3	512.4	1	185.8	136.3
16	20957	178.7	151	175.6	138.6	159.3	526.2	1.1	177.3	156.2
17	21083.2	188.4	144.1	182.9	132.8	160.7	530.5	1.1	184.2	145.7
18	21882.8	190.4	147.6	184.1	127.3	165	542	1.1	185.8	146.6
19	21966.9	184.2	153.6	184.2	141	163	538.9	1.1	180.2	154.8
20	22247.5	192.6	148.7	186.4	127.8	164.6	546.5	1.1	184.1	148
21	23369.7	193.1	154.8	187.9	141	167.9	548.4	1	187.1	151.3
22	23776.5	196.6	154.7	190.3	137.2	171.7	554.8	1	190.2	149.9
23	24057	195	158.6	188.9	146.8	172.5	562.4	1	191.1	161.2
24	27283.3	198.2	177.6	199.4	159.1	181.9	607.3	1.1	201.4	184.1
25	29022.7	211.6	176.7	210	164.8	188.3	621.8	1.1	208.1	179.3

G.woodi 1137A 4R CC Hole 3

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	10815.1	122.8	112.8	125.6	107.2	113.8	366.5	1	125.6	115.2
2	12821.1	141.8	115.8	142.4	105.5	123.7	407.4	1	139.6	118.2
3	13059.5	142.3	117.7	137.4	108.6	124.8	408.8	1	138.6	118.5
4	13087.6	144	116.8	141.2	110.7	125.7	414.4	1	140.6	113.6
5	13648.7	147.6	119.3	143	111.7	128.6	423.8	1	144.1	121.9
6	13662.7	150.2	116.8	148.5	112.7	130.7	422.6	1	150.2	120.9
7	13859.1	155.1	114.3	149.5	105.5	130	426.7	1	153	116.8

8	14602.5	151	123.8	145.4	112.7	132.4	432.9	1	145.6	121.2
9	14883.1	163.5	116.4	157.9	105.5	136	440.9	1	159.2	114.8
10	15107.5	145.2	134	149.2	127.8	135.1	440.2	1	149.5	135.7
11	15514.3	156	127.7	154.8	121.5	137.5	449.6	1	153.6	132.5
12	17197.6	161	137.9	160.8	130.7	144.9	479.2	1.1	165.2	141.1
13	18165.5	168.2	139.8	163.5	120.9	148	494.3	1.1	162.7	142.1
14	18488.1	167.9	142.6	166.2	132.4	151.1	501.9	1.1	170.9	144.5
15	18516.2	163.4	145.8	162.6	137.7	150.2	489.8	1	163.9	146.7
16	19245.6	175.3	141.2	166.9	132.4	153.5	501.8	1	169.8	145.7
17	19456	184.9	135.7	180.9	124.7	156.1	513.1	1.1	182.2	138.2
18	19975	180	143.5	172.8	125.9	159.5	521.8	1.1	174.1	146.2
19	20241.6	180.8	144.1	175.6	132.4	157.5	516.7	1	177.3	148.9
20	20662.4	177.5	149	171.8	137.5	159.7	512.7	1	172.9	147.7
21	23706.3	198	153.9	192.8	132.4	172	564.1	1.1	190.8	153.8
22	24533.9	182.2	172.8	184.4	163.6	172.2	562.5	1	188.3	178
23	25445.7	195.9	166.4	196.6	162.6	177.2	575.8	1	198	173.6
24	29373.4	211.7	177.9	210.9	171.9	189.3	615.5	1	210.6	178.8
25	32824.1	226.6	185.7	225.9	172.9	200.6	655.3	1	224.4	185.9

G.woodi 1137A 4R CC Hole 4

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	11656.8	142.4	104.9	135.1	90	117.1	390.2	1	135.3	101.3
2	12147.7	136.3	114	133.4	105.5	120.5	390.9	1	135	113.6
3	12779	139.2	118.2	139.8	108	123.4	405.4	1	139.5	120.8
4	14855	147.4	130.2	142.6	119.9	134.1	439.8	1	145.3	131.3
5	15093.5	154.8	125.2	150.6	114.1	136.4	440.2	1	149.1	125.6
6	16370	159.3	131.7	156.1	121.8	141	459.5	1	155.7	132.7
7	16468.2	157.9	133.9	156.3	125.6	141.2	460	1	157.4	135.7

8	16566.4	167.2	127.3	160.1	115.4	141.8	465.2	1	160.7	125.5
9	17744.7	169	134.4	164.2	123.6	146.7	478.1	1	161.7	132.7
10	19063.3	173.2	141.8	168.6	129.8	153	504.8	1.1	168.6	143.9
11	20129.3	184.1	140.6	180.9	130.7	156.9	518.3	1.1	182.7	141
12	20325.7	173.3	150.8	172.9	140.8	157.9	516.5	1	172.3	156.4
13	20858.8	185.8	144.2	179.5	130.4	161	523.3	1	180.5	146
14	21223.5	181.4	149.9	178.4	139	162	521.4	1	180.2	149.3
15	21223.5	189.9	142.7	184.5	133	160.8	522.9	1	184.8	143.3
16	21307.6	181.2	151.2	181.2	142.4	160.5	528.4	1	182.6	154.4
17	21532.1	187.9	147	182.9	131.6	162.6	526.7	1	182.3	149.1
18	21742.5	177.6	157	180.1	150.6	162.1	529.7	1	181.5	160.6
19	21882.8	178.3	157	178.1	147.5	162.5	528	1	181	163.9
20	21924.8	185	151.6	183.2	142.4	163.9	531.5	1	182.5	152.5
21	22191.4	185.5	154.1	187.9	144.1	165.4	543.9	1.1	186.5	158.9
22	23103.1	191.1	154.8	184.8	138.8	167.3	545.2	1	180.1	150.1
23	23285.5	186.1	160.4	187.2	154.2	168.7	548.3	1	186.3	169.6
24	23944.8	187.1	164.2	184.4	154.1	170.7	559.1	1	182.9	168.8
25	24141.2	194.9	159.1	187	142.6	172.4	562.4	1	184.7	157.8

M.limbata 872C 3H CC Hole 1

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	223358	600.8	474.9	610.1	431.9	527.5	1786	1.1	605.3	482.2
2	227230	606.6	480.2	601.2	447.3	531	1775.1	1.1	583.9	489
3	250165	626.4	512	631	461.9	558.2	1847.6	1.1	634.2	513.8
4	255706	664.9	493.6	692.9	453.9	562.6	1953.4	1.2	694.5	509.5
5	266100	648.1	527.3	647.9	470.1	575.4	1968.5	1.2	645.3	533.6
6	266170	661.3	518.7	655.9	439.9	573.9	1986.2	1.2	654.5	543.8
7	269130	630.3	546.6	650.3	530.8	580.3	1926.8	1.1	649.7	565.4

8	301744	662.3	583.2	679.6	527	614.7	2030.4	1.1	672.5	571.3
9	326516	731.4	571.7	728.9	516.2	637.6	2140	1.1	731.4	569.1
10	333516	754.1	566.4	739.1	521.7	643.5	2141.3	1.1	729.4	567.1
11	338481	693.8	625.1	728.3	584.6	651.9	2225.8	1.2	705.2	648.7
12	339842	733	593.4	725.5	541.2	651.2	2136.5	1.1	732.5	584.4
13	342648	691.6	634.1	697.3	575.9	656	2173.4	1.1	688.9	630.5
14	343293	746.1	591.9	753.1	466.1	652.9	2368.6	1.3	744	628.3
15	348946	729.7	612.1	721.3	564.5	660.6	2195.4	1.1	716.5	611.4
16	354964	742.1	612.6	749.1	556.1	665.8	2213	1.1	745.3	622.9
17	355889	709.2	640.3	715.1	590.1	669.2	2254.8	1.1	700.9	647.2
18	433671	811.1	683.4	809	618.3	737.1	2425.2	1.1	804.9	666.1
19	461418	843.3	699.3	828.9	661.8	760.2	2502.4	1.1	830.2	707.8
20	582488	940.3	795.4	975.7	731.1	854	2883.7	1.1	970.5	835.7

M.limbata 872C 3H CC Hole 2

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	305952	707.4	554.9	716.8	519.7	616.7	2096.2	1.1	713.4	578.3
2	342620	749.2	585.8	737.2	543	653.5	2200.1	1.1	717.9	595.7
3	365624	734.1	635.5	737.5	584	677.9	2264.2	1.1	738.4	646.3
4	376888	784.5	614.3	775.5	586.6	685.7	2282.8	1.1	784.5	625.6
5	385936	796.6	625.3	816.5	569.7	692.1	2354.5	1.1	805.2	677.9
6	436828	819.8	681.9	842.3	599.1	738.9	2515	1.2	834.2	670.8
7	464139	885.7	670.2	886.4	625.6	760.3	2560.2	1.1	885.3	661.9
8	570523	976.6	746.2	987.2	671.9	843.5	2818.8	1.1	989.2	743.2

M.limbata 872C 4H 1 59-61 Hole 1

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)

1	328452	720.7	587.1	732.4	545.3	639.3	2185.2	1.2	730.4	603.8
2	394409	786.5	650.9	846.4	599	700.2	2620.3	1.4	816.8	661.4
3	397523	751.6	676.6	765.6	634.4	706.3	2336.3	1.1	760.5	669.9
4	426237	793.3	686	803	629.2	731.6	2409.4	1.1	803.5	689.5
5	452847	836.2	692.5	842.6	648.4	752.9	2490.8	1.1	838.2	685.3
6	466650	897.1	668.1	901.5	609.7	761.4	2756	1.3	906.8	685.5
7	491633	887.9	709.1	910.8	663.6	783.9	2664.3	1.1	910.2	738.5
8	498001	892.7	716	889.2	652.3	788.2	2683	1.2	889.1	713.7
9	508634	887.3	736.4	885.4	654.6	796.9	2696.9	1.1	880.8	737.2
10	541584	950.5	729.3	960	667.8	821.5	2783.6	1.1	964.8	741.5
11	556159	945.3	756.4	982.8	683.6	832.7	2880.8	1.2	967.7	803.8
12	589067	952.8	793.9	952	767	858.3	2891.8	1.1	942.6	831.2
13	599307	999.5	769.4	1003.7	696.8	863.8	2924	1.1	1004.6	783.2
14	622494	1000.1	797.2	989.5	692.7	882.5	2955.4	1.1	972.3	800.3
15	625987	988.2	810.5	990.4	731.1	885.5	2930.6	1.1	988.9	832.7
16	380395	758.4	644.2	779.6	598.1	689.7	2306.6	1.1	783.7	678.3
17	431231	816.9	678	825.9	600.8	733.4	2457.6	1.1	805.4	682
18	442649	821.7	690.5	814.5	621.5	744.1	2502.9	1.1	805.4	688.8
19	479275	884.1	695.6	875	643	772.9	2561.3	1.1	877	718.3
20	512141	905.5	724.1	894.7	640.9	799.8	2661.1	1.1	883.3	734.3
21	545947	942.7	743.4	963.4	696.9	825.2	2747.3	1.1	958.5	787.1
22	555794	915.6	777.4	933.1	712.2	834.8	2833.8	1.1	931.9	796.8
23	573525	942.6	777.5	951.4	731.6	847.8	2798	1.1	960.3	789.4
24	609898	984.3	795.6	985.2	691.3	872.7	2945.3	1.1	989	819.8
25	648782	1015	822.7	1035.2	738.7	899.3	3094.1	1.2	995.6	838.9

M.limbata 872C 4H 1 59-61 Hole 2

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)

M.limbata 872C 4H 1 59-61 Hole 3

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	338131	771.2	560.7	766.8	520.3	647.2	2161.9	1.1	769.8	571
2	365358	727.5	641.8	734.6	581.5	677.5	2251.3	1.1	734.2	647.6
3	377464	770.2	626.2	767.2	590.3	687.1	2249.7	1.1	769.4	638.2
4	389457	804.9	618.8	823.3	591.1	697.1	2332.6	1.1	823.3	632.5
5	422520	855.6	632	861.3	589.1	724.6	2462	1.1	856.5	651.8
6	447460	896.7	639.6	899.8	617.4	744.2	2482.9	1.1	899.3	650.6
7	447825	852.5	672.2	848.4	593.7	747.2	2554.9	1.2	848.6	667.2
8	468263	937.5	640.6	951.2	606	759.5	2605.8	1.2	949	661.9
9	472780	887.7	681.5	878.1	635	767.6	2537.5	1.1	873.9	697.5
10	483862	874.2	709.4	890.5	648.4	777.9	2584.5	1.1	869.9	727.4
11	487312	897.8	696.2	918.8	658	778.3	2638.5	1.1	910.7	718.1
12	542973	927	751.5	945.8	696.6	823.1	2751.5	1.1	928.9	764
13	549496	917.2	765.5	933.9	701.8	830.2	2763.1	1.1	939	773.9
14	560058	945.2	757.4	937.7	655.2	836.9	2786.9	1.1	940.9	756.8
15	615593	1044	761.6	1030.5	664.5	872	3047.3	1.2	1058.4	780.2
16	259311	692.3	479.6	699.2	470.7	565.3	1918.1	1.1	701	497.7
17	349002	731.3	612	725.7	535.2	660.3	2187.3	1.1	725.1	617.6
18	411648	833.5	634	814.8	555.8	714.9	2405.5	1.1	819.9	633.8
19	414720	855.9	621.9	878.5	595	717.2	2416	1.1	879.3	649.8
20	428467	810.7	677.3	823.4	624.6	732.4	2431.8	1.1	818.9	669.2
21	471461	872.1	692.7	855.2	639.8	767.4	2551.3	1.1	856.4	698.4
22	522353	929.2	721.7	927.7	667.7	806.7	2723.1	1.1	915.6	740
23	561138	928.5	771.4	921.1	726.9	839.3	2761.5	1.1	921	776.1
24	562036	958.2	753.3	958.6	702.6	836.9	2777.6	1.1	949.6	767.1
25	579332	979	759.5	994.6	697.8	849.9	2879.2	1.1	986.5	795.7

1	306373	717.5	545.6	718.9	515.8	617.3	2049.8	1.1	725.2	567.9
2	314424	725.3	557.1	727.1	511.8	624.7	2108.4	1.1	727.8	559
3	401927	866.4	599.4	893	560.5	702.9	2491	1.2	887	640.2
4	411676	805.8	655.3	831.4	618.2	716.7	2375.6	1.1	824.9	686.4
5	456592	860	681.6	854.9	615.6	754	2562.2	1.1	858.6	695.8
6	468530	841.8	715.5	868.2	648.2	765.4	2546.8	1.1	841.6	729.5
7	474379	870.5	699.8	879.7	648	768.9	2575.9	1.1	879.3	710
8	477703	869.9	702.7	883.3	665.9	772.8	2553	1.1	882	722.6
9	481014	896	686.3	891.5	635.9	774.3	2582.9	1.1	882.7	700.9
10	519589	940	711.5	988.3	656.7	802.9	2774.5	1.2	960.9	741.6
11	549117	985.6	722.8	991.6	622.3	822.1	2920.8	1.2	991.3	768.9
12	553171	928.3	765	926.9	672.7	831.2	2824.3	1.1	886.5	767.7
13	576779	950.8	778	931.8	680.4	848.9	2868.9	1.1	929.8	784.4
14	588632	942.4	799.8	950.3	752	859.1	2831.1	1.1	927.2	838
15	635414	1003.9	810.8	1022.5	756.6	891.8	2987.7	1.1	1000.7	826.7
16	332113	727	586.4	722.9	517.7	643.1	2149.9	1.1	727.3	610
17	359845	752	614.1	741.6	542.8	670.4	2233.4	1.1	742.2	602.1
18	361248	751.5	615.2	762.9	570.8	671.9	2247.5	1.1	765.4	631.1
19	381251	750.6	651.5	755.2	586.2	690.7	2322.5	1.1	716.3	640.1
20	404017	821.4	631.6	840.9	591.2	709.2	2376.2	1.1	840.6	655.7
21	422253	832.8	649.2	844.6	601.5	725.2	2415.4	1.1	839.2	660.3
22	426560	850	645.7	866.9	590.1	727.4	2446.5	1.1	853.1	667.4
23	450350	857.5	672.9	858.2	599.5	748.7	2513	1.1	839.3	678
24	454867	837.2	695.1	849.5	674.6	754.6	2515.6	1.1	841.6	702.1
25	475501	828.3	736.2	842.7	693.9	772.3	2525.3	1.1	838.5	755

M.limbata 872C 4H 1 59-61 Hole 4

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)

M.multicamerata 872C 4H 1 59-61 Hole 1

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	198418	569.6	445.5	567.8	406.9	496.3	1666.8	1.1	566.7	438.3
2	272384	665.8	521.9	672.8	509.5	583	1933.4	1.1	673.6	530.2
3	274460	643.7	546.4	654.6	516.5	585	1945.8	1.1	654.5	561.9
4	292093	659	565.8	665.9	522.2	604.9	1969.8	1.1	654.6	568.9
5	329350	717.7	587.6	718.5	536.1	641.4	2133.4	1.1	724.5	611
6	345846	726.9	609.6	735.8	578.9	657.5	2165.9	1.1	725	629.6
7	363422	751.6	618	750.7	589	674.1	2222.8	1.1	737.5	625
8	370436	806.3	587.4	802.6	552.1	677.7	2275.9	1.1	804	585.5
9	396639	791.2	644	793.9	599.9	703.1	2358.5	1.1	802.8	657.2
10	400960	804.3	638.4	812.7	596.6	706.9	2380.2	1.1	815.7	652.4
11	442691	871.8	649.3	867	601.4	742.2	2476	1.1	865	662.8
12	447685	837.7	682.8	847.6	626.6	748.9	2475	1.1	856.7	683.1
13	452987	812.3	717.6	845	672.3	752.8	2548.6	1.1	847.8	755.3
14	481491	883.6	699.6	890.9	639.5	774.3	2620.1	1.1	889.2	709.6
15	485867	889.3	698.4	907.9	663	779.1	2599	1.1	909.3	701
16	521188	936.8	710.9	930	666.7	805.8	2675.8	1.1	937.5	703.6
17	521834	919.4	727.2	920.1	666.7	807.4	2684.3	1.1	908.8	731.1
18	544839	969.9	721	986.6	626.6	822.3	2905.3	1.2	955.5	769.5
19	558712	956.1	748.6	943.9	676.2	834.9	2855.5	1.2	940.4	753.7
20	563748	919.1	785	925.7	702.4	840.3	2834.2	1.1	927.3	759.8
21	282807	685.9	528.3	683.8	475.7	593.1	1968.8	1.1	685	538.4
22	380143	756.8	643.3	759.5	602.5	689.6	2289.8	1.1	763.3	652.1
23	386048	783.9	632	796.1	577.7	693.7	2337.8	1.1	784.7	659
24	417806	815.5	657.9	822.6	609	721.7	2399.3	1.1	825.8	677.2
25	481519	908.9	681.4	900	590.6	772.7	2695.8	1.2	901.1	716.2

1	365821	734.8	636.9	751.2	576.6	676.7	2238.9	1.1	727	641
2	382275	851	575.4	856.6	528.7	685.7	2333	1.1	859.8	582.6
3	407300	788.8	659.4	793.5	627.1	714.5	2338.1	1.1	795.7	676.7
4	408534	808.9	646.5	820.4	620.2	714	2360	1.1	800.3	661.5
5	483146	829.1	744.8	831.4	683.1	779.4	2559.9	1.1	820	734.8
6	483791	868	711.8	872.9	681.7	778.7	2531.5	1.1	873.6	713.7
7	561700	952.1	755.4	952.9	673.4	837.5	2809.7	1.1	959.3	764.8
8	566020	935.9	774.1	954.2	715.4	842.1	2791.4	1.1	951.5	789.7
9	634081	1014.5	799.5	1014	737.9	890.2	3012.6	1.1	1013.1	817.5
10	639313	971.8	840.6	970.8	768.5	896.5	2930.7	1.1	970.1	837
11	661294	1010	839.8	1020.1	802.1	910.3	3198	1.2	1026	866.6
12	724460	1093.5	850.8	1095	759.1	950.1	3240.1	1.2	1068.4	879.4
13	729832	1043.8	899.4	1053.6	793.7	955.8	3232.2	1.1	1017.2	884.2
14	747927	1103.9	870	1123.9	773	966.5	3407.8	1.2	1083.5	891.6
15	816536	1129.8	925.9	1137.5	869.8	1011.8	3428.8	1.1	1133	957.1
16	437992	810	691.6	826.2	660	741.3	2485.1	1.1	792.3	698
17	462343	848.5	698.2	837.7	635.4	760	2578	1.1	854.8	708
18	489963	875	716.2	875	664.7	783.1	2597	1.1	874.2	721
19	492825	835.7	752.5	841.8	716.2	787.2	2553.9	1.1	827.4	758.8
20	507315	879.6	735.8	878.1	692.1	798	2612.3	1.1	878.9	743.2
21	534108	917.1	744.8	903.5	691.4	817.4	2715.4	1.1	921.2	746.8
22	574394	981.5	750.7	983.7	696.6	845.7	2853.9	1.1	982.7	762.9
23	588688	943.1	798.7	966.4	750.7	859.3	2888.9	1.1	953.3	814.8
24	646762	992.6	833.3	1003.9	760.1	900.6	3069.6	1.2	995.4	824.4
25	752879	1089.7	885.8	1112.3	834.7	970.9	3262.8	1.1	1111.1	909.6

M.multicamerata 872C 4H 1 59-61 Hole 2

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)

1	447699	824	694	828.5	647	749.4	2438.3	1.1	827.5	703.8
2	510906	897.9	730.2	877.2	642.1	798.6	2706.6	1.1	878.2	719.1
3	550183	935.1	757.2	952.8	700.2	828.7	2812.2	1.1	951.1	784.1
4	555261	991.5	717.9	999.8	689.1	830	2848.3	1.2	1013.8	744.6
5	556089	1000.4	718.1	1016.6	653.1	828.7	2860	1.2	1019.5	766.6
6	623855	1012.2	793.3	1027.6	703.9	882	3053.1	1.2	1016.4	821.9
7	677804	1019.2	851.2	1042.3	821.2	923.7	3060.4	1.1	1020.1	864.3
8	683275	1021.3	858.2	1014.7	767.1	925.4	3092.1	1.1	1001	879.9
9	728584	998	934.5	1027.4	842.3	958.6	3204.7	1.1	989.9	951.4
10	815848	1087.4	961.4	1101	857	1013.2	3389.9	1.1	1064.9	965.3
11	879098	1209.3	934.3	1204.9	829.1	1046.5	3611.9	1.2	1212.3	961.9
12	989297	1267	1001.8	1282.6	870.4	1111.2	3776.7	1.1	1280.2	1046.2
13	485741	886.5	701.2	898.9	649.2	779.1	2618.4	1.1	902.7	712.8
14	495841	906.8	703.3	923.5	622.6	785	2713	1.2	895.2	729.7
15	501241	952.9	680.3	934.4	600.7	784.7	2735.2	1.2	934.6	697.1
16	509840	903.2	722.7	926.7	654.1	798.3	2669.1	1.1	920.1	748.3
17	513010	905.7	725	895.2	663.4	800.3	2710.9	1.1	895.9	728.7
18	568292	968.5	756	978.2	675.1	840.2	2990.8	1.3	968.2	792
19	586837	969.6	777.7	953.3	680	855.3	2894.2	1.1	951.2	793.7
20	872421	1188.4	947	1202.9	834.8	1042.3	3551.4	1.2	1200.2	988
21	596936	981.9	780	967.1	731.1	862.9	2934.9	1.1	970.6	797.6
22	603557	985.9	784.5	987.9	722.8	868.2	2972.7	1.2	991.5	808.6
23	999565	1284.9	1000.1	1293	885	1115.7	3816.9	1.2	1284.2	1008.9
24	602056	1021.6	758	1001.4	658.3	863.6	2977.7	1.2	1009.1	754.7
25	859754	1224.8	902.1	1232.2	815.7	1033.7	3551.2	1.2	1211.4	935.2

M.multicamerata 872C 4H 1 59-61 Hole 3

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)

M.multicamerata 872C 4H 1 59-61 Hole 2

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	480832	851.6	721.3	834.4	687.9	776.6	2524.9	1.1	836.6	713.8
2	484591	891.9	699.9	905.9	618.3	775.7	2653.2	1.2	900.3	731.8
3	508704	894.5	728	892.9	689.1	797.9	2630.5	1.1	881.1	740.6
4	521118	907.8	734.1	912.3	681.2	806.8	2671.2	1.1	917.2	749.3
5	535693	916.8	748.4	921.2	683.4	818.8	2731.8	1.1	914.5	754.8
6	540939	897.7	771.7	935.6	726	824.1	2768.1	1.1	942.4	802.7
7	544965	928.8	754.9	929.9	730.1	824.9	2785.3	1.1	940.2	801.6
8	562359	944.4	764.6	936.3	716.8	838.2	2804	1.1	951.1	770.9
9	569457	1029.3	709.4	1035.1	628.5	838.2	2904.2	1.2	1027.1	716.2
10	571463	953.8	766.3	964.8	715.4	845.8	2810.3	1.1	957.8	788.2
11	588043	941.4	806.4	957.6	722	856.4	3001.1	1.2	949.2	815.6
12	590596	937	804.6	938.2	736.3	861.1	2875.5	1.1	938	811.1
13	666021	1027.7	828.8	1015	752.2	913.5	3010.3	1.1	1013.5	826.1
14	716099	1037.6	882.1	1039.3	816.5	948.5	3100.8	1.1	1031.6	869
15	981540	1208.9	1046.8	1241.3	974	1108.8	3869.6	1.2	1234.8	1109.3
16	365540	747.6	627.5	749.5	559.9	675.8	2263.6	1.1	731	642
17	423894	833.9	655.2	818.1	571.3	725.3	2465.1	1.1	808.5	662
18	470423	844.2	712	846.4	644.2	768.2	2549.5	1.1	846.4	717.1
19	561686	991.3	730.7	992.5	669.7	834.1	2945.1	1.2	997.3	771.7
20	563986	924.9	781.2	940.3	706.1	840.6	2800	1.1	932.6	775.5
21	590217	961.2	786.5	965.1	701.2	859.5	2876.5	1.1	965.2	799.8
22	606307	998.6	779.2	1026.9	700.8	869.9	3001.1	1.2	1028.5	826.1
23	607345	966.9	802.8	977.2	771.8	873	2909.5	1.1	984.2	828
24	656791	1042.2	807.5	1034.9	730.8	904.9	3025.3	1.1	1019.5	818.3
25	826944	1117.2	950.3	1151.4	830.9	1018.2	3659.8	1.3	1068.8	965.3

1	450967	825	699.3	838.5	672.4	751.8	2480.6	1.1	838.7	715.2
2	453001	834.9	695.7	856.5	641.6	752.7	2507.8	1.1	825.4	713.3
3	462203	846.7	700	840.3	624.6	759.9	2516.7	1.1	837.1	722
4	465668	837.3	711.1	838.1	659.2	763.8	2559.3	1.1	844.4	705
5	470269	875.5	690.1	891.3	647.9	765.2	2572.7	1.1	887.1	722.1
6	492544	857.6	733.8	852	678.8	786.4	2596.6	1.1	841.8	726.6
7	502013	891.5	721.1	920.4	693.4	795.3	2673.2	1.1	923	735.8
8	537544	914	755.2	923	688.3	819.6	2781.2	1.1	910.2	774.6
9	563327	956.4	757.3	966.6	710.5	838.1	2864.5	1.2	965.4	785
10	570200	1038.7	706.4	1021.7	624.4	836.6	2876.2	1.2	1013.8	722.3
11	612240	967.7	812.5	992.7	754	875.2	2942.5	1.1	970.3	830.9
12	634305	1030.7	790	1024.9	726.1	888.2	3053.9	1.2	1026.3	813.1
13	636564	1012.8	802.9	1008.3	734.4	892.6	3011	1.1	1012.9	809.1
14	674662	1023.8	844.6	1023.3	757.4	919.7	3142	1.2	1014.3	850.7
15	685898	1031.6	851.3	1048.5	775.1	927.3	3118.2	1.1	1032.9	885.6
16	331005	722.8	588.2	725.3	550.1	642.1	2164.3	1.1	728.3	614.8
17	363899	774.1	603.4	764.1	537.7	672.9	2240.4	1.1	761.3	606.4
18	399599	816.7	626.9	821.1	557.9	705.1	2372.1	1.1	812.7	653.3
19	432984	810.2	685.6	813.1	611.6	735.5	2458.1	1.1	795.6	681.9
20	442649	901.2	633	910.4	581	738.2	2585.6	1.2	916.8	688.1
21	489066	896.8	700.7	905.5	661.4	779.9	2641.7	1.1	908.7	736.2
22	510275	896.8	731.4	898.6	649.9	798	2722.8	1.2	888.6	750.5
23	543197	961.8	726	946.1	651.7	821.2	2763.5	1.1	934.5	733.5
24	590975	955.6	793	980.1	770.7	860.2	2893.3	1.1	974.7	825.2
25	602309	953.5	807.5	949.5	726	868.5	2884.7	1.1	937.5	819.1

M.multicamerata 872C 3H 1 59-61 Hole 1

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)

1	384996	776.4	634.3	776	593.3	693.7	2298.4	1.1	784.9	654.8
2	399950	753.8	678.5	761.4	641.5	707.8	2343.3	1.1	761.3	679.4
3	431483	809.1	680.9	818.5	630.5	735.6	2424.5	1.1	812.4	679.3
4	453590	822.8	703.9	836.7	655.1	754.6	2477.4	1.1	835.7	707.3
5	460899	905.4	654.5	931.7	625.8	755.7	2567.9	1.1	920.6	665.7
6	525775	908.8	738.4	924	714.8	811.8	2746.8	1.1	903.3	755.1
7	569611	953.8	763.8	953.4	706.6	844.1	2796.7	1.1	958	776.9
8	579136	933.8	791.7	955.9	736.7	852.8	2830.2	1.1	951.3	802.1
9	688283	1033.7	855.4	1047.4	774.2	927.9	3169.6	1.2	1051.6	879.5
10	823185	1139.3	931.4	1123.6	815.4	1012.2	3521.8	1.2	1133.4	936.6

G.subquadratus 872C 11H CC Hole 1

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	99580.6	377.3	343.8	384.6	323.1	354.5	1181.9	1.1	388.6	346.8
2	100072	392.1	329.2	389	289.6	352.6	1197.4	1.1	380.7	322
3	110873	417.1	354.8	420.1	329.3	377.5	1308.1	1.2	416.6	367.2
4	123427	443.3	361.4	435.4	319.4	393.4	1339.1	1.2	422.8	356.3
5	132952	447.7	386.7	444.5	342.1	407.9	1385	1.1	430.7	393.4
6	138577	480.7	371.1	472.4	297.4	413.8	1409.4	1.1	467.2	363.9
7	138619	483.5	372.5	476.6	316.4	415.3	1429.3	1.2	476.1	367.8
8	141298	464.4	396.5	466.2	342.5	420.5	1443.4	1.2	448.7	399.4
9	141298	496	375.7	489.1	342.5	421.8	1453.9	1.2	490.5	381.5
10	145170	478.7	392.2	478.5	346.7	425.3	1431.1	1.1	475.1	399.1
11	147835	489.6	391.5	482.7	338	428.7	1468.6	1.2	472.9	393.5
12	159870	506.6	416.3	498.7	354	451.9	1549.2	1.2	484.8	410.8
13	162297	500.2	417.9	497.3	380.1	448.8	1504.6	1.1	492.7	430.6
14	163181	541.3	392.6	535.6	352.1	450.8	1556.3	1.2	536.8	397.9

15	163433	505.8	421.9	500.2	362.9	453.7	1556.8	1.2	499.4	423.4
16	163812	522.6	402.3	520.3	318.6	449.7	1536.7	1.1	512.6	403.6
17	166884	538.4	402.7	530.6	331.3	455.5	1582.4	1.2	528.7	404
18	166898	523.7	417.8	527.7	380.3	458.1	1565.6	1.2	524.5	427.1
19	168932	542.3	407	546.2	382.8	459.7	1572.8	1.2	544.9	423
20	178232	530.4	438.2	528.7	386.7	472	1632	1.2	512.8	447.5
21	181908	554.9	423.6	546.4	370.2	472.9	1647	1.2	547.1	441.6
22	185246	543.8	439.1	535.4	382.8	479.4	1695.5	1.2	533.9	448.5
23	189370	548.7	446.3	552.3	417.4	484	1655.2	1.2	553.2	472.4
24	204632	601.6	440.2	582.8	329.6	500.3	1789.9	1.2	576.7	441.8
25	215279	591.4	470.2	586.5	410.3	516.1	1769.3	1.2	581.9	484

G.subquadratus 872C 11H CC Hole 2

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	84501.1	374.3	303.2	374.9	278.9	330.6	1123.2	1.2	373.7	309.7
2	100394	401.9	322.5	401	297.4	352.7	1196.6	1.1	402.7	331.1
3	103045	409.1	324.4	407.2	270.3	356	1220.5	1.2	393.8	320.1
4	117872	441.8	347.4	428.4	297.5	384	1313.1	1.2	426.9	339.6
5	118476	436.4	353.7	433.1	301.2	385.9	1296.2	1.1	431.9	355.1
6	120425	449.3	343.6	443.5	309.2	385	1301.9	1.1	442.4	344.8
7	128505	449.3	369.8	449	323.5	398	1370.4	1.2	438.5	370.8
8	131788	456.4	370	455.4	308	403.8	1361.8	1.1	452.5	375.5
9	134972	465.6	377.2	458.2	325.9	410.3	1413.6	1.2	444.7	378.3
10	135743	465.3	379.9	457.2	318.4	413.3	1399.9	1.1	442.5	373.3
11	136010	471	372.3	466.9	304.8	411.4	1385.4	1.1	465.6	376.1
12	136389	450.8	401.9	452.9	361	417	1417.8	1.2	448.9	419.7
13	140947	480.8	377.9	475.7	325.8	416.7	1531.2	1.3	473.8	386
14	141775	472.2	385.5	460.7	316	418.8	1418.6	1.1	452.2	375.4

15	143094	465.3	402.7	465.6	366.5	424.5	1446.8	1.2	460.7	412.4
16	164668	521.9	408.2	517.7	346.2	451.8	1557.6	1.2	510.4	410.7
17	165327	531	408.3	516.2	341.2	454.4	1570.3	1.2	507.5	418.9
18	165622	513.2	422	501.8	356.5	457.9	1548.3	1.2	486.1	409
19	167501	539.1	398.7	531.8	322.1	454.3	1570	1.2	529.5	394.8
20	171163	540.4	424.3	532.7	325.9	469.5	1628.2	1.2	520.5	418.6
21	178709	544.7	423.2	534.5	356.3	471.7	1584.9	1.1	535.5	419.5
22	185120	541.2	451.3	540.3	382.8	480.7	1679.7	1.2	520.8	473.8
23	194588	556.7	451.2	548.7	380.1	491.3	1681.2	1.2	533.3	453.4
24	210495	578	474.4	579.8	415.1	512.5	1795.5	1.2	571	490.8
25	213006	598.1	465.1	602.1	413.4	516	1781.9	1.2	597.1	481.6

G.subquadratus 872C 11H CC Hole 3

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
1	73643.9	334.5	282.6	335.4	250.9	300.9	1009.1	1.1	333.9	282.4
2	75888.3	343.6	285.4	340.8	260	305.3	1028.8	1.1	336.9	292.9
3	89859.6	366.3	329.7	374.9	300	340.1	1165.5	1.2	362.9	341.1
4	96747.1	397.3	314	387.4	273.4	345.4	1168	1.1	384.6	311.8
5	98402.3	394.6	319.6	387.5	269.7	348.6	1163.8	1.1	381.4	312.6
6	101460	407	328.5	402.2	282.1	358	1258.3	1.2	395.4	323.7
7	113103	437.1	334	430.5	278.1	374.6	1270.9	1.1	427.8	332.6
8	114183	429.7	350.1	426.9	292.2	381.2	1308.9	1.2	421.7	346.9
9	128968	447.1	373.1	449.1	332	399	1384	1.2	443.9	381.8
10	129277	461.1	364.5	452.5	333.9	401.2	1367.1	1.2	446.2	370.3
11	129908	468.1	368.5	467.4	316.4	406.8	1422.8	1.2	464.9	371.7
12	131240	464	367.2	460.7	323.5	404.9	1379.5	1.2	457.2	362.3
13	134341	462.7	372.1	453.9	319.4	407.9	1367.6	1.1	450.9	375.9
14	134425	469.6	368.4	466.4	322.1	406.8	1388.9	1.1	461	373

15	139138	469.9	384.9	475.7	372.8	418.4	1408	1.1	477.7	395.4
16	144538	487.3	386.2	487.3	337.2	425.7	1473.3	1.2	482.2	388.9
17	144637	497.4	386.3	498	332.9	427.5	1491.9	1.2	485.7	386.1
18	145647	490.7	384.3	485.5	329.6	425	1454.5	1.2	479.3	380.8
19	147835	493.5	384.9	483.4	327.2	426.9	1475.1	1.2	476.8	380.1
20	151945	505.6	396	506	361.1	437.5	1514.5	1.2	505.5	409.1
21	154652	513.6	393.9	499.4	329.7	440	1525.3	1.2	498.7	397.1
22	163546	513.3	415.7	509.4	351.2	452.8	1547.8	1.2	496.3	410.5
23	165523	523.7	406.7	509.7	356.9	453.4	1544.6	1.1	503.5	402
24	169732	528.5	415	520.3	330.7	459.5	1583	1.2	514.5	406.6
25	171738	528.1	430.7	520	373.5	466.9	1624	1.2	502.3	441.3

G.subquadratus 872C 11H CC Hole 4

Obj#	Area	Axis (major)	Axis (minor)	Diameter (max)	Diameter (mi	Diameter (m	Perimeter	Roundness	Size (length)	Size (width)
289	91206.2	380.1	310.5	376.2	258.7	337.6	1134.5	1.1	375.9	314.2
630	98037.6	387.5	329.7	390.4	303.2	351.2	1179.7	1.1	392.1	332
470	105360	409.8	336.8	404	302.1	363.3	1254.6	1.2	396.8	337.9
55	118069	439	360.4	437.3	314.6	390.5	1353	1.2	429.7	365.4
417	122684	439.3	368.5	439.7	337.2	393.2	1347	1.2	431.4	381.8
609	123890	446.7	355.9	440.5	324.7	391.7	1325.7	1.1	438.8	360.3
468	125545	462.2	358.4	462	289.3	399.2	1378.4	1.2	449.8	346.6
50	129810	455.1	371.9	445.8	325.8	403.9	1370.2	1.2	441.2	374.1
620	130862	449.7	381	452.7	351.4	405.6	1416.2	1.2	451.1	389.2
304	133485	475.6	367.6	480.9	339.4	408	1412.6	1.2	479.6	380.6
146	135519	443.4	400.5	447.6	369.3	412.4	1418.4	1.2	443.3	409.7
269	135533	489	363.5	482.2	319.4	412	1456	1.2	481.8	361.1
323	138030	470.1	377.6	466.9	327.2	412.9	1410.3	1.1	461.5	382.7
613	138661	491.2	361.8	483.4	322.1	412.9	1409.3	1.1	486.8	364.4

66	140092	470.8	383.3	476.8	370	416	1414.2	1.1	473.6	394.4
56	140358	474.5	386.1	466.4	330.9	420.4	1421.3	1.1	458.5	381
163	150851	476	414.9	475.8	383.6	434	1538	1.2	470.7	442.3
627	161498	518.1	399.6	511.2	346.2	447	1494.4	1.1	512.3	407.2
454	162311	519.9	401.3	517.4	343.7	448	1526.7	1.1	515	407.9
148	177840	540.4	424.6	535.2	348.2	468	1621	1.2	532.9	428
420	186102	570.1	429.4	560.4	337.1	482.2	1700.6	1.2	554.3	434.6
308	190128	560.1	442.8	556.3	389.5	486.5	1706.7	1.2	556.9	455
135	192133	557.2	446.3	552.3	363.3	488.7	1690.6	1.2	541.4	439.9
142	194350	573.9	443.5	569.9	361.1	493.6	1728.4	1.2	567.4	443.6
41	202696	577.4	458.2	583.8	367	501.1	1772.2	1.2	573.6	466.3

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A phylogeny of Cenozoic macroperforate planktonic foraminifera from fossil data

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ABSTRACT

We present a complete phylogeny of macroperforate planktonic foraminifer species of the Cenozoic Era (∼65 million years ago to present). The phylogeny is developed from a large body of palaeontological work that details the evolutionary relationships and stratigraphic (time) distributions of species-level taxa identified from morphology ('morphospecies'). Morphospecies are assigned to morphogroups and ecogroups depending on test morphology and inferred habitat, respectively. Because gradual evolution is well documented in this clade, we have identified many instances of morphospecies intergrading over time, allowing us to eliminate 'pseudospeciation' and 'pseudoextinction' from the record and thereby permit the construction of a more natural phylogeny based on inferred biological lineages. Each cladogenetic event is determined as either budding or bifurcating depending on the pattern of morphological change at the time of branching. This lineage phylogeny provides palaeontologically calibrated ages for each divergence that are entirely independent of molecular data. The tree provides a model system for macroevolutionary studies in the fossil record addressing questions of speciation, extinction, and rates and patterns of evolution.

Key words: planktonic foraminifera, macroevolution, Cenozoic, biodiversity, phylogeny, stratophenetics, morphospecies, speciation, extinction, pseudoextinction.

CONTENTS

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I. INTRODUCTION

The fossil record has long been a major source of evidence for the study of evolution (Simpson, 1953; Gould, 2002; Benton, 2009) and is a rich source of information about past environments and biodiversity. Changes in diversity can be tracked and correlated against palaeoenvironmental data to address questions of fundamental biological importance: what happens to global or local biodiversity in response to rapid climate change? Is the world full of species? Are speciation and extinction rates diversity-dependent? Is the likelihood of speciation dependent on species age? How do character change, speciation and extinction combine to cause an evolutionary trend?

The fossil record presents two kinds of problem for studies of macroevolutionary dynamics. The first is that the fossil record contains biases that result from the way in which the record is deposited and sampled. Some taxa, locations and periods of geological time are more thoroughly sampled than others and this lack of uniformity produces an observed diversity of fossils that is not necessarily a faithful reflection of underlying diversity patterns (McKinney, 1991; Paul & Donovan, 1998; Kidwell & Holland, 2002). Much research effort has been directed at filtering out these biases to produce a more accurate picture (Foote, 1992; Smith, 2007; Alroy *et al.*, 2008; Rivadeneira, Hunt & Roy, 2009) This is one reason why a major recent research effort in the palaeobiological community has been the construction of large occurrence-based databases, such as the Paleobiology Database (http://www.paleodb.org/) and NEPTUNE (services.chronos.org/databases/NEPTUNE/index.html). These help to highlight parts of the fossil record that are particularly well represented and those that are not.

The second kind of problem is that palaeobiological taxonomic concepts are typological: due to the absence of genetic information specimens are assigned to species or higher taxa on the basis of morphological characteristics alone and 'species' in the fossil record may be either more or less inclusive than the underlying evolutionary species (Forey *et al.*, 2004). Some extant morphologically delimited species apparently contain multiple genetic species; detailed investigation often, but not always, reveals diagnostic morphological differences (Jackson & Cheetham, 1990; Darling & Wade, 2008).

A related issue arises when specimens from different points in time along a single evolving lineage (i.e. an ancestor-descendant series of populations) are assigned to different named forms. This is a common problem when dealing with fossil groups that have particular biostratigraphic value, because morphologically intergrading forms tend to be arbitrarily split into constituent morphospecies to provide more accurate means for correlating and dating rocks. When this happens, taxa can appear in the fossil record without any cladogenesis ('pseudospeciation') and can disappear without any extinction ('pseudoextinction') (Simpson, 1951; Stanley, 1979; Fordham, 1986). This problem becomes more obvious as the fossil record of a study system approaches completeness. A very complete record can provide a solution: if morphospecies are seen to intergrade through time, they can be assigned to the same evolutionary species (Simpson, 1951; Fordham, 1986; Pearson, 1998*a*).

Aside from the fossil record, evidence on macroevolutionary dynamics also comes from time-calibrated (usually molecular) phylogenies of diversity among extant species, which are increasingly available even for groups with poor fossil records. Per-lineage rates of speciation and extinction can be estimated, under the assumption that they have been constant through time (Nee, May & Harvey, 1994). Patterns, including whether diversification has slowed (Pybus & Harvey, 2000) and explosive radiation of particular groups (Harvey, May & Nee, 1994; Rabosky, 2006; Bininda-Emonds *et al.*, 2007), can be tested using complete or randomly sampled phylogenies of extant species. However, there is a growing appreciation of several limitations inherent in molecular phylogenetic approaches. The inclusion of only extant species, the choice of diverse clades to analyse and the incorrect assumption that all contemporaneous species have the same chances to diversify all bias estimates of underlying rate parameters (Nee *et al.*, 1994; Ricklefs, 2007; Purvis, 2008; Rabosky & Lovette, 2008; Rabosky, 2010). Apparent 'slowdowns' can be caused by artefacts as well as diversity-dependence of speciation and extinction rates (Barraclough & Nee, 2001; Phillimore & Price, 2009; Purvis *et al.*, 2009). More generally, the absence of direct information from fossils can make it hard to differentiate among very different scenarios, especially early in a clade's history (Harvey *et al.*, 1994; Rabosky & Lovette, 2008).

The ideal study system for macroevolution would be a comprehensive phylogeny of all extant and extinct evolutionary species within a clade that combines morphological, molecular and stratigraphic data (Purvis, 2008; Benton, 2009). This is only possible with an exceptionally rich and well-studied fossil record such as is available from the biomineralising ocean plankton. Macroperforate planktonic foraminifera are an extremely abundant and cosmopolitan group. Their excellent preservation potential, combined with the relatively complete (see online supporting information Table S1) and continuous sedimentary successions in which they are found make species-level studies possible. They have one of the best fossil records of any group, especially throughout the Cenozoic Era [~65 Million years ago (Ma) to present] that is our focus.

Here, our aim is to synthesise previous work on the taxonomy and relationships of Cenozoic macroperforate planktonic foraminifera into a phylogeny of all discernible evolutionary lineages, which can then be used as a model system for macroevolutionary research and tested against independent, molecular data.

II. PLANKTONIC FORAMINIFERA

Planktonic foraminifera are unicellular biomineralising marine zooplankton that range from tropical to polar latitudes (Bé, 1977; Hemleben, Spindler & Anderson, 1989). They are most abundant and diverse in the upper mixed layer of the ocean where they commonly predate on larval arthropods and other plankton. Some species specialize in living at depth below the photic zone, typically grazing on sinking phytodetritus. Many upper-ocean forms host photosynthesising algal symbionts (see review in Hemleben *et al.*, 1989). The cell is largely encased in a calcium carbonate test, i.e. 'shell', beyond which a pseudopodial network is commonly extended for feeding. The tests have very diverse morphologies with varying degrees of ornamentation. There are 45 morphologically distinct species with vast geographical distributions in the modern oceans. The majority of modern (36 out of 45) and Cenozoic fossil planktonic foraminifera belong to the Superfamily Globigerinacea, thought to be a monophyletic clade that originated in the Lower Maastrichtian, approximately 70 Ma. Only two species of macroperforate planktonic foraminifera are believed to have survived the end-Cretaceous extinction event 65 Ma, *Hedbergella holmdelensis* and *H. monmouthensis* (Olsson *et al.*, 1999). During the following 65 million years, over 300 different morphospecies are suggested to have descended from these two.

Planktonic foraminifera, along with other types of biomineralising planktonic organisms, contribute significantly to the material deposited on the sea floor and their tests are extremely abundant in biogenous sediments such as pelagic clays and oozes (Seibold & Berger, 1993). The steady accumulation of such sediments, particularly in stable settings, makes it common for millions of years of evolutionary history to be captured in a single place, and for morphospecies to be preserved continuously throughout their existence. Many such sites have been drilled by the Deep Sea Drilling Project (DSDP) and its successors the Ocean Drilling Program (ODP) and Integrated Ocean Drilling Program (IODP) in all the world's oceans and across a wide range of latitudes and environments. Due to continuing IODP work, and further study of geological sections now exposed on land, recovery of additional material will continue to enhance the already excellent geographical and stratigraphical record of this group. Their fossil record is so well documented and its timescale so well established that species can be sampled at will from more or less any time in their history. The resolution of this record, using material from multiple locations, can be as good as 0.01 million years, permitting high-resolution macro- and microevolutionary analyses and palaeoclimatic reconstruction (Cifelli, 1969; Zachos *et al.*, 2001).

Planktonic foraminifera have often been used as biostratigraphic markers or to provide geochemical proxies of oceanic and atmospheric temperatures and chemistry. Their use as biostratigraphic zone fossils means that particular attention has been paid to the dates of first and last occurrences of species in the fossil record; their use as environmental indicators means that much information on the life habitats of species and their changing environments has been obtained directly from geochemical analysis of their tests (Pearson & Wade, 2009). The use of stable isotopes as a proxy for sea-water temperature was pioneered by Emiliani (1954), who demonstrated that the relative depth habitats of various species in a fossil assemblage could be reconstructed from their stable isotope ratios. Subsequent studies have elucidated the depth habitats of many Cenozoic species, including extinct forms for which there is no observational evidence (Pearson, 1998*a*). Stable isotope and trace metal analysis of foraminiferal calcite has been used in the construction of long-term climate records that highlight important periods in the development of Earth's climate system, such as the onset of glaciation at the Eocene-Oligocene transition approximately 34 Ma and the global climatic maximum during Paleocene-Eocene Thermal Maximum (PETM) approximately 55 Ma (Zachos, Dickens & Zeebe, 2008).

The combination of precise dating and detailed records of global climate change throughout the Cenozoic (Zachos *et al.*, 2001, 2008; Lear, Elderfield & Wilson, 2000) provide the means to understand the evolutionary response of planktonic foraminifera to abiotic drivers and address the effects of environmental change on biodiversity (e.g. Wei & Kennett, 1988; Schmidt, Thierstein & Bollmann, 2004; Allen *et al.*, 2006). The group has also been a testing ground for other macroevolutionary theories such as Van Valen's Law of constant extinction (Arnold, 1982; Pearson, 1995; Doran *et al.*, 2006) and Cope's Rule of size increase through time (Arnold, Kelly & Parker, 1995; Webster & Purvis, 2002). Detailed morphometric analyses have provided evidence of both phyletic gradualism (e.g. Malmgren & Kennett, 1981) and abrupt speciation (Hull & Norris, 2009). As in other plankton groups, however, there is also significant cryptic genetic diversity (De Vargas *et al.*, 1999; Darling *et al.*, 2003; Darling & Wade, 2008).

In the past 20 years, molecular analysis of extant planktonic foraminifera has provided increasing evidence of non-trivial 'cryptic speciation' that is not readily detectable though morphological examination. Distinct genetic types within morphospecies have mostly been detected using a single gene in small subunit ribosomal DNA (SSU rDNA) sequences, which has provided new information about the evolutionary history of the group. For example, prior to genetic studies, it had been thought that the right-coiling *Neogloboquadrina pachyderma* and the left-coiling *N. incompta* were one species, with coiling direction being an ecophenotypic response to temperature (Ericson, 1959). Genetic studies, however, have revealed substantial divergence between the two forms, that may have occurred during the late Miocene approximately 10 Ma; their fluctuating abundance down particular ocean sediment cores is now thought to reflect fluctuations in the location of the polar front that serves as the range boundary between the two species (Darling *et al.*, 2004, 2006). Other examples of inferred cryptic speciation include *Orbulina universa* (three distinct types: de Vargas *et al.*, 1999) and *Globigerinella siphonifera* (seven types: Darling & Wade, 2008). The existence of such deeply diverged cryptic genotypes suggests that the traditional, strictly morphometric approach underestimates biodiversity (Darling & Wade, 2008).

The discovery of multiple genetic types has prompted detailed re-examination of the calcite tests to discover more about foraminiferal biology. In the cases outlined above (and others in the literature: Darling & Wade, 2008) these studies have highlighted the significance of sometimes subtle morphological differences when delimiting species, such as, for example, test wall porosity in both *Orbulina* (Morard *et al.*, 2009) and *Globigerinella* (Huber, Bijma & Darling, 1997) and coiling direction in *Neogloboquadrina* (Darling *et al.*, 2006). The genetic studies on planktonic foraminifera emphasize the benefits of considering the ecology (de Vargas *et al.*, 1999; Darling *et al.*, 2004, 2006) and biogeography (de Vargas *et al.*, 1999; Darling, Kucera & Wade, 2007; Aurahs *et al.*, 2009) of organisms when applying palaeontological species concepts. The genetic work does not demand unilateral abandonment of traditional palaeontological species concepts; integrating both sorts of data with ecological information is likely to yield the most comprehensive understanding of any group's evolutionary history (Dayrat, 2005; Will, Mishler & Wheeler, 2005). A large phylogeny based on fossil data is valuable as a hypothesis of the evolutionary relationships of planktonic foraminifera that can be tested with molecular data (although genetic data may be unable to resolve patterns of rapid branching in the distant past: Rokas, Krüger & Carroll, 2005). Additionally, phylogenetic trees constructed using distinct single genes (collected in this instance from restricted sampling locales in relation to the vast geographical distribution of many of these species) can imply very different phylogenetic structures that bear little resemblance to the underlying species tree (Maddison, 1997). Large-scale SSU rDNA phylogenies on the scale of the fossil phylogeny we present here have not yet been constructed due to incomplete sampling and the simple fact that most included species are extinct. The phylogeny presented here has been purposefully constructed without reference to genetic data, and contains ecological information through assignment of each morphospecies to an ecogroup based on stable isotope analysis of their calcium carbonate tests and geographical information on habitat preference.

Planktonic foraminifera, both fossils and living, have a long history of taxonomic work and revision. This work has, with hindsight, proceeded in several phases prompted by the appreciation of the usefulness of particular species and groups of species in biostratigraphy, by technological advances that opened up new sets of characters for study, and by changes in systematic philosophy and practice. Table 1 summarises major developments in planktonic foraminiferal research since their discovery in 1826.

III. TERMINOLOGY

Mayr (1942, p. 120) defined biological species as 'groups of actually or potentially interbreeding natural populations which are reproductively isolated from other groups'. When applying species concepts to fossil data workers typically apply the rules laid out in the *International Code of Zoological Nomenclature* (ICZN, 1999). This means that populations are assigned to species on the basis of morphological similarity to their respective holotypes in the absence of information on the behaviour of the species in question. A species that is defined with reference to a specific holotype and which represents a point in morphospace is a typological species. Species can be also be defined with more flexibility as a general morphology representing a sector of morphospace that includes the type; such a species is referred to as a morphological species (Smith, 1994; Forey *et al.*, 2004; Pearson *et al.*, 2006). The species-level taxa, named using Linnaean binomial nomenclature, are regarded as morphospecies in this work and include typological and morphological species.

The morphospecies phylogeny presented in this work depicts the stratigraphic ranges and hypothesised evolutionary relationships of fossil and recent macroperforate planktonic foraminifer morphospecies. Central to the construction of the phylogenies within this work is the concept of an evolutionary lineage (or lineage). Simpson (1961, p. 153) regarded the lineage as a single line of descent and described it as 'an ancestral–descendant sequence of populations evolving separately from others with its own unitary evolutionary role and tendencies'; this is also known as an evolutionary species (Simpson, 1951; Wiley, 1978; Mayden, 1997). According to this concept, the phenotypes displayed by members of an evolutionary lineage may change through time; it is the continuity, rather than the presence of any diagnostic character, that delimits the lineage. Operationally, continuity is inferred from temporal phenotypic dynamics, and different lineages are recognised by disjunctions in phenotypes among specimens from the same time (Fordham, 1986; Mayden, 1997; Pearson, 1993, 1998*a*). Artificial boundaries based on changes in morphology cut through the evolutionary lineages in order to subdivide successive populations. Although these morphological changes may fully intergrade if no partitions were made, completely different fossils would then be classified together (Fig. 1).

From a biostratigraphic perspective, it is useful to subdivide lineages as finely as possible to achieve the maximum possible stratigraphical resolution. The importance of planktonic foraminifera as biostratigraphic markers means that lineages within the group have been subject to much fine-scale splitting. Consequently many of the morphospecies appear

Table 1. Major themes and progress in the history of planktonic foraminiferal phylogenetic and taxonomic research

Date	Major themes and progress	Reference
1826–1839	Planktonic foraminifera were described from beach sands and classified as cephalopods.	d'Orbigny (1826, 1839 *a*, *b*, *c*)
1839–1899	Further discoveries of planktonic foraminifera in deep-sea sediments and rocks. The planktonic nature of several species became widely accepted after dredging reports from the *Challenger* Expedition (1872-1876).	Ehrenburg (1861, 1873); Carpenter *et al.* (1862); Parker & Jones (1865); Gümbel (1868); Hantken (1875); Brady (1884); Murray & Renard (1891)
	The utility of planktonic foraminiferal distributions as climate and water mass indicators was discovered.	Murray (1897)
1900–1911	First investigations into planktonic foraminiferal biology were published.	Rhumbler (1901, 1911)
1912–1949	Detailed systematic research into planktonic foraminifera flourished when their use for stratigraphic correlation of rocks became appreciated, particularly due to the expansion of oil exploration in the early 20th Century. A relatively simple taxonomic approach developed, dividing genera by major features of test morphology and apertural position.	Cushman (1927*a*, *b*, 1933); Finlay (1939, 1940); Subbotina (1947)
1950–1968	Stable isotope analysis of foraminiferal calcite was first used to infer oceanic palaeotemperatures and species depth habitats.	Emiliani (1954, 1955)
	Worldwide study produced detailed investigations into global distributional patterns.	Phleger (1951); Parker (1954, 1960, 1962); Sigal (1958); Bradshaw (1959); Bé (1959, 1960); Boltovskoy (1964, 1966 *a*, *b*); Lipps (1966); Cifelli (1969)
	Major taxonomic synthetic works produced the first phylogenetic trees; evolutionary convergence was recognised and some pre-existing genera were split.	Bronnimann (1952); Subbotina (1953); Bolli (1957 *a*, *b*); Loeblich *et al.* (1957); Morozova (1957, 1960, 1961); Banner & Blow (1959); Hofker (1959); Leonov & Alimarina (1960); Alimarina (1962, 1963); Blow & Banner (1962); Wade (1964); Berggren (1968) & McGowran (1968)
1969–1979	From 1969 the Deep Sea Drilling Program began to provide many new relatively continuous sediment records from throughout the Cenozoic. The use of scanning electron microscopes (S.E.M.) from the late 1960s led to rapid advancements in the understanding of the phylogenetic evolutionary history of planktonic foraminifera. Some workers began to recognise the significance of wall ultrastructure for identifying phylogenetic affinity and began developing a more natural higher taxonomy.	El Naggar (1971); Jenkins (1971); Postuma (1971); Steineck (1971); Bandy (1972, 1975); Collen & Vella (1973); Fleisher (1974); Stainforth *et al.* (1975); Steineck & Fleisher (1978); Blow (1979)
1980–1989	Ongoing ocean drilling and widespread use in the exploration industry led to significant further advances in the synthetic taxonomy and biostratigraphy of planktonic foraminifera.	Saito *et al.* (1981); Srinivasan & Kennett (1981*a*, *b*); Kennett & Srinivasan (1983); Bolli *et al.* (1985); Cifelli & Scott (1986); Fordham (1986); Wei (1987); Stanley *et al.* (1988)
1990–present	Establishment of taxonomic working groups affiliated to the International Commission on Stratigraphy produced a systematic revision of all fossil planktonic foraminifera based on S.E.M. investigation of all available original type material, with a strong emphasis on wall ultrastructure analysis to delimit higher taxonomic groupings.	Chaproniere (1992); Pearson (1993, 1998*a*); Spezzaferri, (1991, 1994); Chaisson & Pearson (1997); Olsson *et al.* (1992, 1999); Pearson *et al.* (2006)
	Extraction and analysis of foraminiferal genetic material provides a new method of taxonomic identification and evidence of cryptic speciation which highlights the importance of integrating molecular and traditional morphological taxonomic approaches for the most comprehensive understanding of planktonic foraminiferal evolution.	Pawlowski *et al.* (1994*a*,*b*, 1996); Darling *et al.* (1996, 1997, 1999, 2004, 2006, 2007); De Vargas & Pawlowski (1998); De Vargas *et al.* (1999); Pawlowski & Holzmann (2002)

to be intergrading forms belonging to the same lineage as other morphospecies: they do not arise through cladogenesis, and they do not disappear through extinction of any lineage (Fordham, 1986; Pearson, 1993, 1998*a*) (Fig. 1).

The lineage phylogenies presented here depict only cladogenetic speciation events, with morphospecies merged together into their respective lineages. Therefore, the branches within each lineage phylogeny represent the ranges

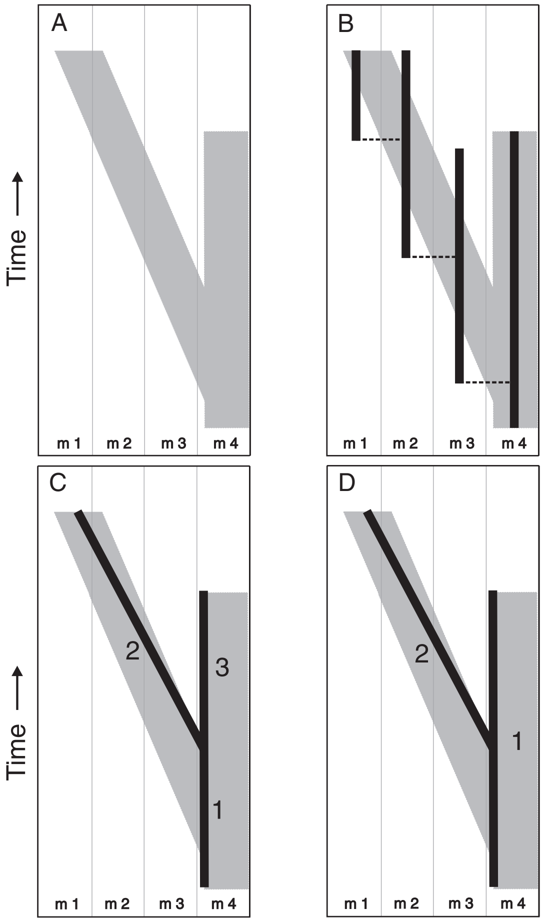

Fig. 1. A schematic illustration of how morphospecies and lineages are represented on a phylogeny. (A) The box represents morphospace and the grey boxes within it areas of morphospace occupied by fossil populations. This has been divided by the vertical lines into four distinct morphospecies, morphospecies 1 (m 1) to morphospecies 4 (m 4), which are separated from one another on the basis of morphological dissimilarity. (B) An illustration of how the fossil populations would be represented on a morphospecies phylogeny. The solid black vertical lines represent the stratigraphic ranges of the morphospecies and the horizontal dashed black lines represent the inferred evolutionary relationships between them. (C) An illustration of how the fossil populations would be represented on a lineage phylogeny using a Hennigian species lineage concept. It highlights the arbitrary nature of the morphospecies concept, the boundaries between morphospecies are defined by taxonomic workers principally to aid biostratigraphic work, but evolutionarily it is clear that the fossil populations illustrated above are fully intergrading and therefore belong to one lineage. Only when there is empty morphospace between populations in multidimensional space can a speciation event be inferred. There are three Hennigian lineages, one internode lineage (1) and two terminal lineages (2 and 3). (D) An alternative 'evolutionary' lineage phylogeny. In this case there are no internode lineages and all lineages end in an extinction event. Lineages are permitted to persist through speciation events if there has been no change in morphology between one of the descendant Hennigian species and its ancestor (1 and 3 in C). Consequently there are only two 'evolutionary' lineages rather than three as in C.

and relationships of evolutionary lineages though time, rather than the morphospecies (Figs 1 and 2). Branches that end at a splitting event (cladogenesis) are non-terminal branches, whereas terminal branches end in extinction. The two lineage phylogenies (Fig. 3A,B, see also online supporting information, Appendix 5) correspond to different lineage concepts. The Hennigan species concept (Hennig, 1966; Meier & Willmann, 2000) equates species with internodes, such that species cease to exist either through extinction or through speciation. The evolutionary species concept (Simpson, 1951; Wiley, 1978) differs in recognising the possibility that an ancestral species can persist through a speciation event; the completeness of the foraminifera fossil record makes it possible to assess whether an ancestor persists without apparent morphological change (Figs 1 and 2).

IV. METHODS AND RESULTS

(1) A phylogeny of morphospecies

It is common in the literature to depict stratigraphic ranges of morphospecies with connections that denote supposed evolutionary relationships, and the morphospecies phylogeny was derived from literature of this kind (see online supporting information; Appendix 1, (B) Table S3). Work synthesising information on standardised taxonomy and phylogenetic relationships was favoured where available. All species that were recognized as a distinct species in at least one major taxonomic work were included in the phylogeny; a degree of subjectivity regarding which species were included was inherent in this approach. Until every single divergence has been resolved by means of quantitative morphometrics at multiple localities on a centennial scale, phylogenetic hypotheses for the whole clade over the entire Cenozoic can only be made by tracing sequences of occurrences of species through strata based on their overall morphological similarity. Where there was conflicting information in the literature, the most up-to-date publications presenting an integrated taxonomy from well-defined stratigraphic sections were favoured. We have not included taxa that are recognised on the basis of genetic evidence, such as *N. incompta*, as only a minority of even the extant morphospecies have been investigated in this way. PLANKRANGE (http://palaeo.gly.bris.ac.uk/Data/plankrange.html), an online database of planktonic foraminifera, was used in conjunction with an exhaustive literature search in order to eliminate synonymy. Dates of first and last appearances were converted where necessary to the biozonation timescales of Berggren *et al.* (1995), Berggren & Pearson (2005) and Wade *et al.* (2011). These timescales have been astronomically and paleomagnetically calibrated, and their use will facilitate future revisions of the trees as and when they are updated over the coming years.

Most of the literature underpinning the morphospecies phylogeny used a stratophenetic approach (Gingerich, 1976). The aim of stratophenetics is to reconstruct

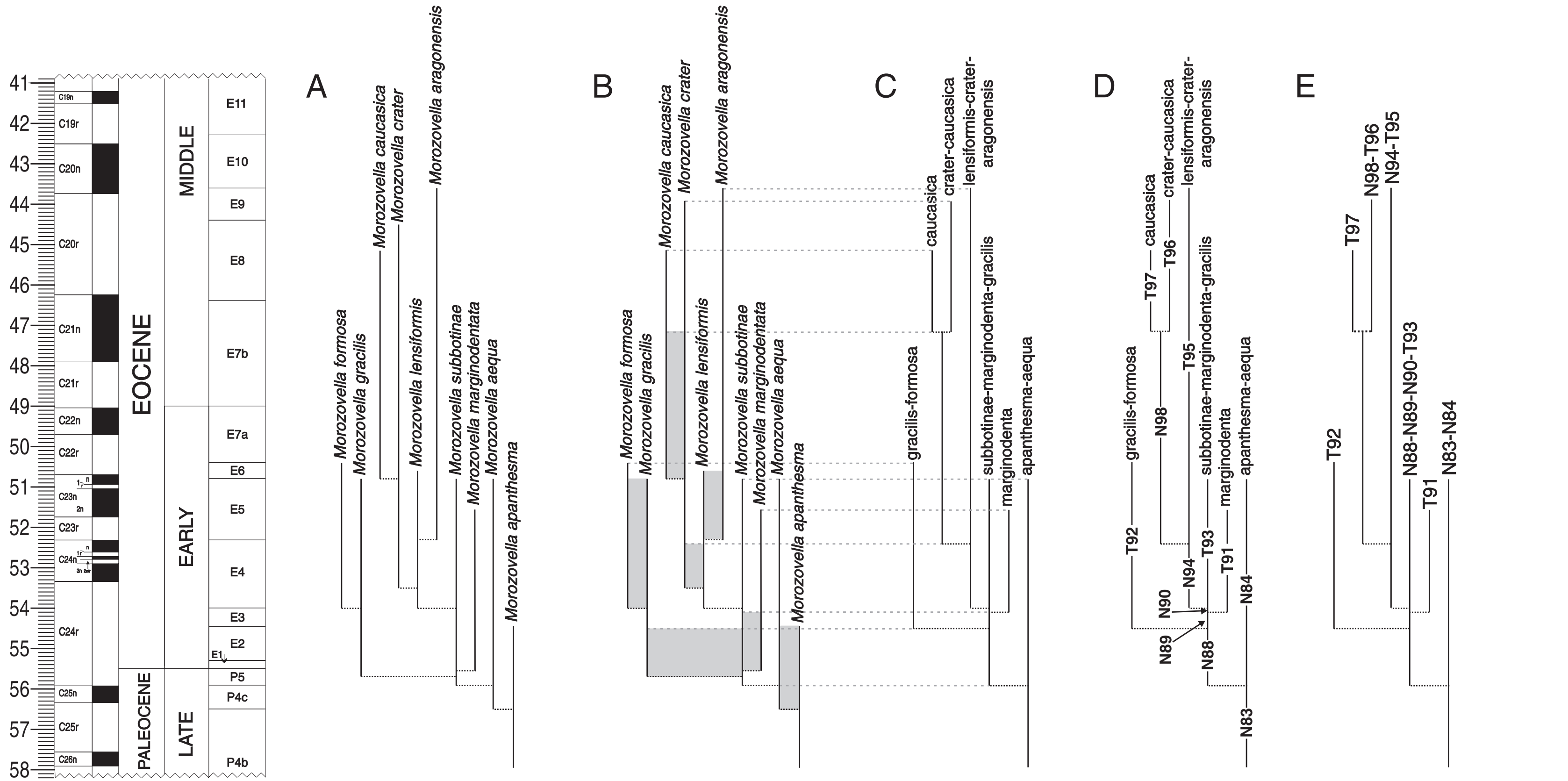

Fig. 2. An example from this review of how the lineage phylogeny is derived. (A) Part of the morphospecies phylogeny of the genus *Morozovella*. (B) Morphological intergradation of the morphospecies is indicated by the grey blocks; merging these together removes pseudospeciations and pseudoextinctions. (C) The resulting 'evolutionary lineage' phylogeny now illustrates the relationships between lines of descent rather than morphospecies. Note the reduction in the length of many branches and the merging of multiple morphospecies into single branches (the grey dashed lines are included to aid comparison). Cladogenetic events may be bifurcating such as the caucasica and crater-caucasica lineages, or budding as in the rest of the clade. (D) Because the Latin binomial names of the morphospecies are no longer applicable, lineages are given unique concise codes. Every internode in the phylogeny is assigned an arbitrary number, prefixed with a 'T' for terminal lineages and 'N' for non-terminal lineages. (E) In the resulting lineage phylogeny all numbers that represent one evolutionary lineage (evolutionary lineage according to Simpson, 1951) are grouped together in a chronological sequence at the end of each lineage. The corresponding morphospecies names that are included in these lineages can be found in Appendix 1, Table S3, columns headed species name and LID (see online supporting information).

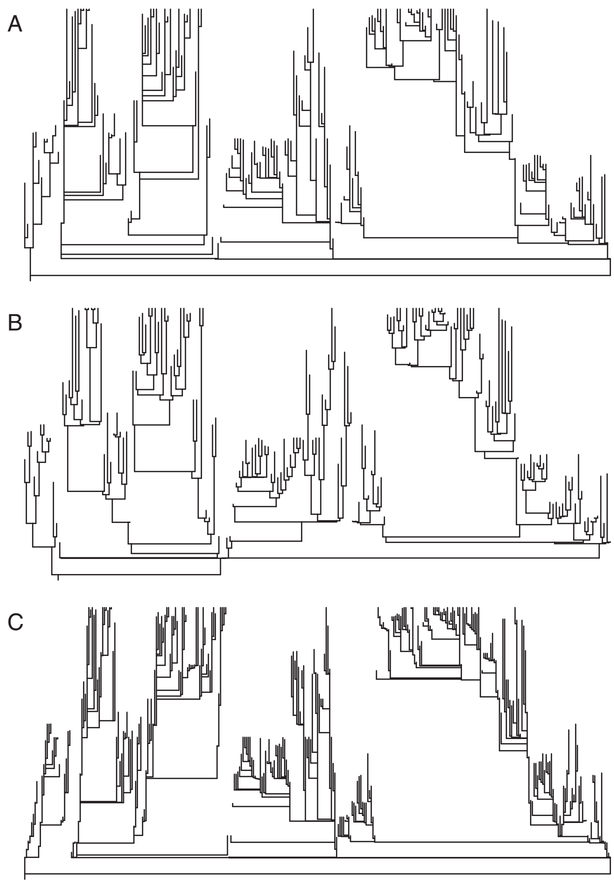

Fig. 3. A schematic showing the three complete phylogenies arranged similarly. (A) The evolutionary lineage phylogeny. (B) The Hennigian lineage phylogeny. (C) The morphospecies phylogeny. Tip and node labels are provided in the online supporting information (Appendix 1, Table S3, columns headed ID and LID) and Fig. 5. These figures were drawn using paleoPhylo (Ezard & Purvis, 2009) in the R environment (version 2.10.1, R Development Core Team, 2010).

ancestor-descendant relationships of fossil organisms based on "(1) quantitative assessment of morphological (phenetic) similarity, interpreted within the context of (2) independent evidence of geological age" (Gingerich, 1992, p. 437). Stratophenetics incorporates time when trying to elucidate genealogical relationships (Gingerich, 1992). Phylogenetic hypotheses are also often constructed through cladistics, using synapomorphies (shared derived characters) as evidence of relationship among species (Hennig, 1966; Smith, 1994). Cladistics is particularly valuable for groups with a poor fossil record, where information about ancestor-descendant relationships is limited, but has significant limitations when constructing a phylogeny for large groups with a long history and good fossil record. The cladistic method excludes stratigraphic information and is particularly sensitive to homeomorphy, which is rife within planktonic foraminifera due to widespread temporally distinct convergent evolution (Cifelli, 1969; Banner & Lowry, 1985; Norris, 1991). The over 300 Cenozoic macroperforate morphospecies are identified on the basis of few easily recognisable, discrete morphological characters, and are known for their convergent morphological evolution (Coxall *et al.*, 2007; Norris, 1991); convergence due to a limited repertoire of morphologies leads to 'character exhaustion', resulting in homoplasy eroding the hierarchical signal in character data (Wagner, 2000). Cladistic analyses of planktonic foraminifera suffer from extensive homoplasy, with the most parsimonious relationships sometimes conflicting with stratigraphy (Stewart, 2003). Combined, these factors can make the outcome of cladistic analysis less meaningful than the inferences derived from carefully tracing evolutionary lineages though the sediment record (Pearson *et al.*, 2006).

The resulting stratophenetic morphospecies phylogeny represents sectors of morphospace, and the stratigraphic ranges represent the times in the past when those sectors of morphospace were occupied by living organisms (Pearson, 1998*a*). First and last occurrences of morphospecies do not necessarily represent genuine speciation and extinction events because gradual anagenetic evolution can result in the appearance of new morphologies (pseudospeciation); similarly the last occurrence of a morphospecies may be caused by evolutionary transition rather than a real extinction (pseudoextinction) (Stanley, 1979). The resulting morphospecies phylogeny is shown in Fig. 3C and 4, with detail in Fig. 5. The phylogenies are available as data and in full-colour plots as online supporting information (see Section XI), which also contains a full appendix listing relevant details used in construction of the phylogenies and divergence times between extant lineages.

Many of the evolutionary relationships depicted are necessarily tentative, awaiting better fossil resolution and more detailed morphometrics that could underpin more robust hypotheses about ancestry. Although Paleocene and Eocene relationships are generally more robust, having been reviewed in the *Atlas of Paleocene Planktonic Foraminifera* (Olsson *et al.*, 1999) and the *Atlas of Eocene Planktonic Foraminifera* (Pearson *et al.*, 2006), the origin of the genus *Dentoglobigerina* is still uncertain (see D in Fig. 4). Due to the absence of spine holes it was suggested by Olsson, Hemleben & Pearson (2006) that *Dentoglobigerina* be derived from the muricate genus *Acarinina* during the Eocene, but an alternative and more traditional hypothesis would derive *Dentoglobigerina* from the subbotiniids with a subsequent loss of spines. We follow the suggestion of a muricate ancestor but uncertainty will persist until more morphological intermediates are discovered.

'Paragloborotalia' kugleri and '*P*'. *pseudokugleri* also have uncertain ancestry dependent on the presence or absence of spines. Both were described as spinose by Spezzaferri (1994) and Rögl (1985), but more recent scanning electron microscope (S.E.M.) observations of extremely well-preserved specimens by Pearson & Wade (2009) found no evidence of spine holes. We have therefore provisionally derived '*P*'. *kugleri* and '*P*'. *pseudokugleri* from *Dentoglobigerina* on the basis of morphological similarity (see Fig. 5D).

The morphospecies phylogeny of Neogene globorotaliids was taken from Stewart (2003), which is a comprehensive

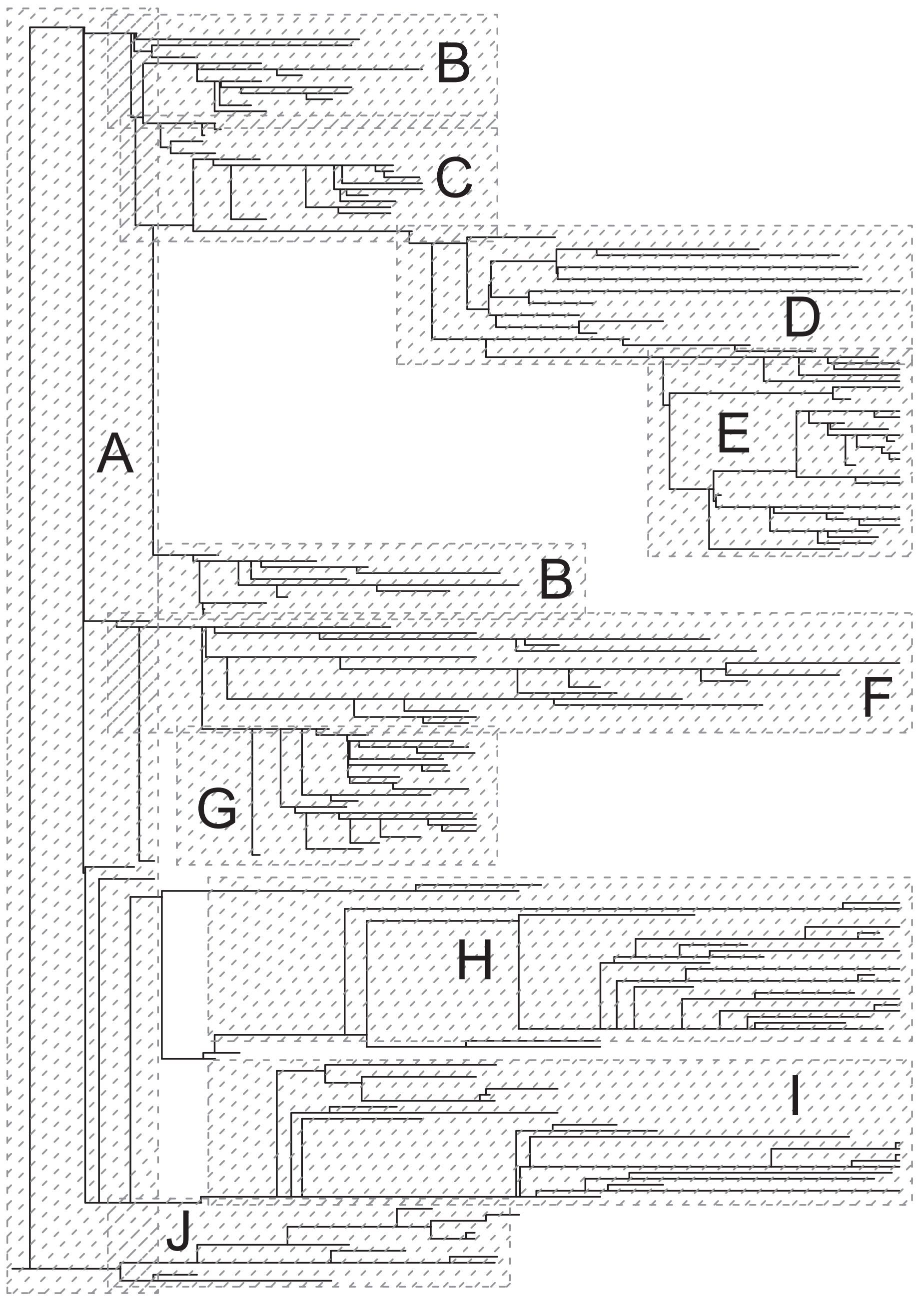

Fig. 4. The lineage phylogeny as a legend; letters correspond to subsequent panels of Fig. 5 containing legible details. For full colour versions, split by eco- and morphogroups, see online supporting information (Appendices 2 & 3). These figures were drawn using paleoPhylo (Ezard & Purvis, 2009) in the R environment (version 2.10.1, R Development Core Team, 2010).

revision of this large group using cladistics, stratocladistics and stratophenetics. The origin of the globorotaliids is contentious. Hilbrecht & Thierstein (1996) proposed that this clade arose from a separate benthic source based on their observations of 'benthic-like' behaviour in laboratory culture; specimens exhibit a crawling motion around the bottom of a Petri dish. Here we derive the ancestor of the globorotaliids (*Hirsutella praescitula*) from *Paragloborotalia kugleri* (Fig. 5D) due to a possible relict cancellate wall texture in *H. praescitula* as suggested by McGowran (1968), Kennett & Srinivasan (1983) Cifelli & Scott (1986) and Spezzaferri (1994).

The genera *Hastigerina* and *Orcadia* were removed from the phylogeny due to the unclear status of this clade. Both genera have tri-radiate, barbed spines unlike any other Cenozoic spinose forms (Holmes, 1984). They also have a poor fossil record (which may be due to their extremely thin and delicate test wall) which makes stratophenetic tracing of their evolutionary history through sediments very difficult.

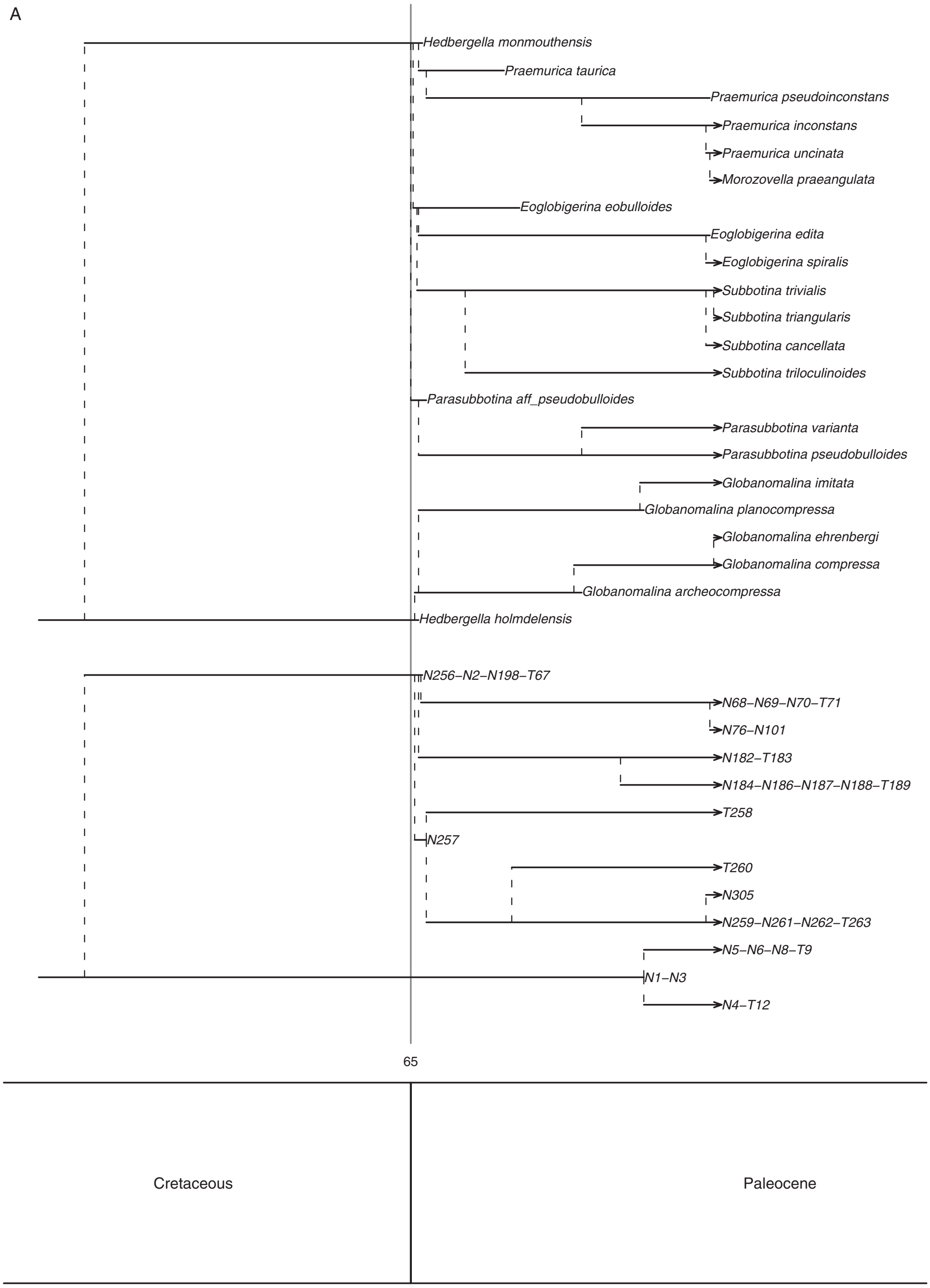

Fig. 5. Morphospecies and lineage phylogenies of Cenozoic macroperforate planktonic foraminifera depicted in 10 panels (A–J). Lineages and morphospecies highlighted with bold lines denote that associated descendants are illustrated in other panels. (A) Descendants of *Hedbergella holmdelensis* shown as both morphospecies (top) and evolutionary lineages (bottom). *(Cont.)*

(2) Conversion to a lineage phylogeny

To completely eliminate pseudospeciation and pseudoextinction from a stratophenetic phylogeny would require detailed morphometric work across the entire phylogeny, in order to identify lineages that diverge in morphospace. Parts of the phylogeny have been the subject of such studies (e.g. Malmgren & Kennett, 1981; Wei, 1987; Stewart, 2003; Hull & Norris, 2009). More commonly, the literature contains qualitative observations that one morphospecies is seen to intergrade with another, or descriptions of last occurrences as pseudoextinctions rather than real extinctions. Even so,

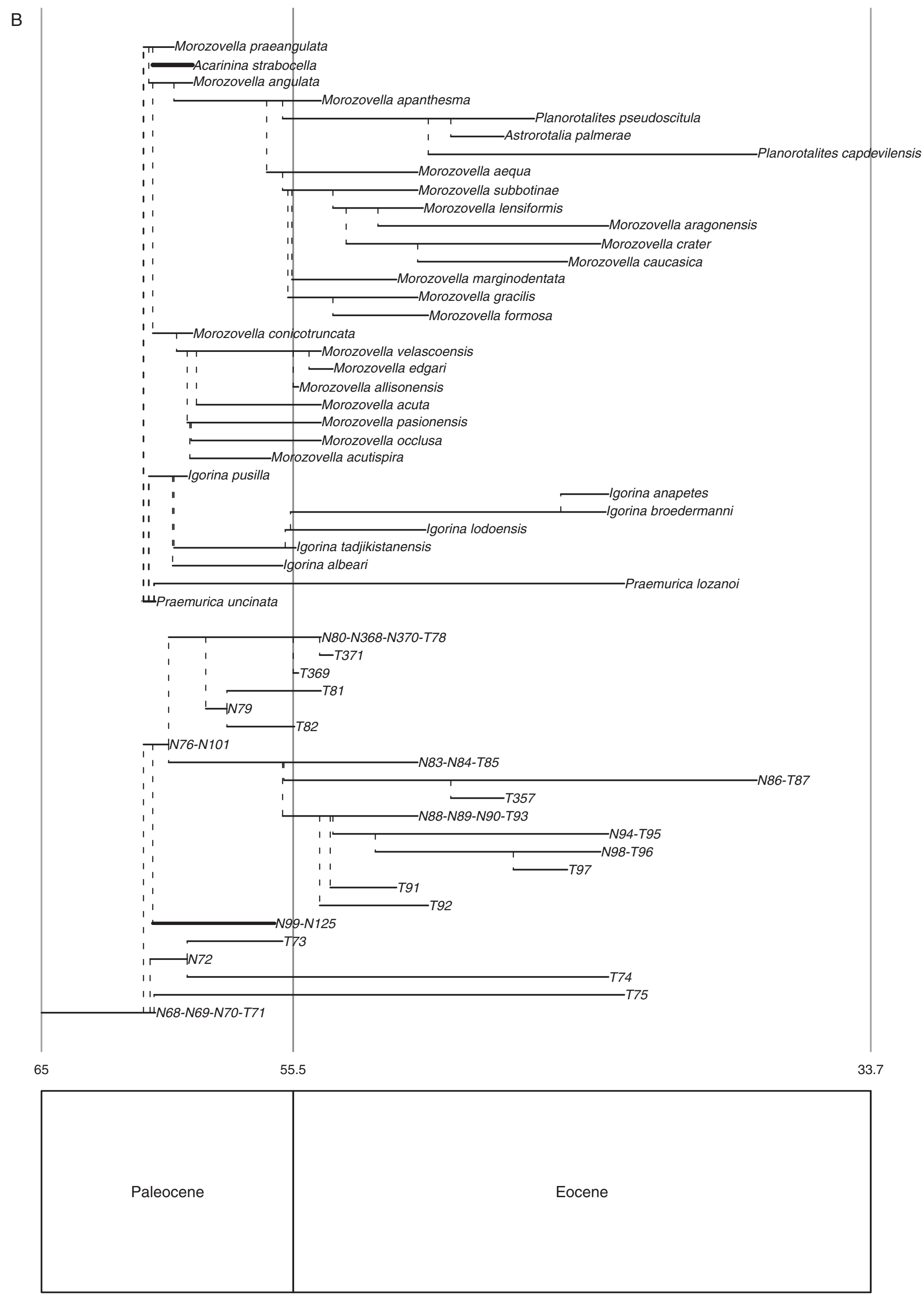

Fig. 5. (B) Descendants of *Praemurica unicinata* shown as both morphospecies (top) and evolutionary lineages (bottom). *Praemurica unicinata* is descended from *Praemurica inconstans* (see A). *Acarinina strabocella* and its corresponding lineage (highlighted with bold lines) have descendants which are detailed in C. *(Cont.)*

we had to make many qualitative decisions on the timing and pattern of individual branching events based on our own observations of the fossil record, discussion with colleagues, and ongoing re-sampling of the phylogeny for a study of size and shape change (T. Aze, unpublished data). 117 of the 297 extinction events (39%) seen in the morphospecies tree are assessed as pseudoextinctions. Segments of branch between adjacent nodes in Fig. 1C, and between a terminal species and its parent node, correspond to what Meier & Willmann (2000) term Hennigian species.

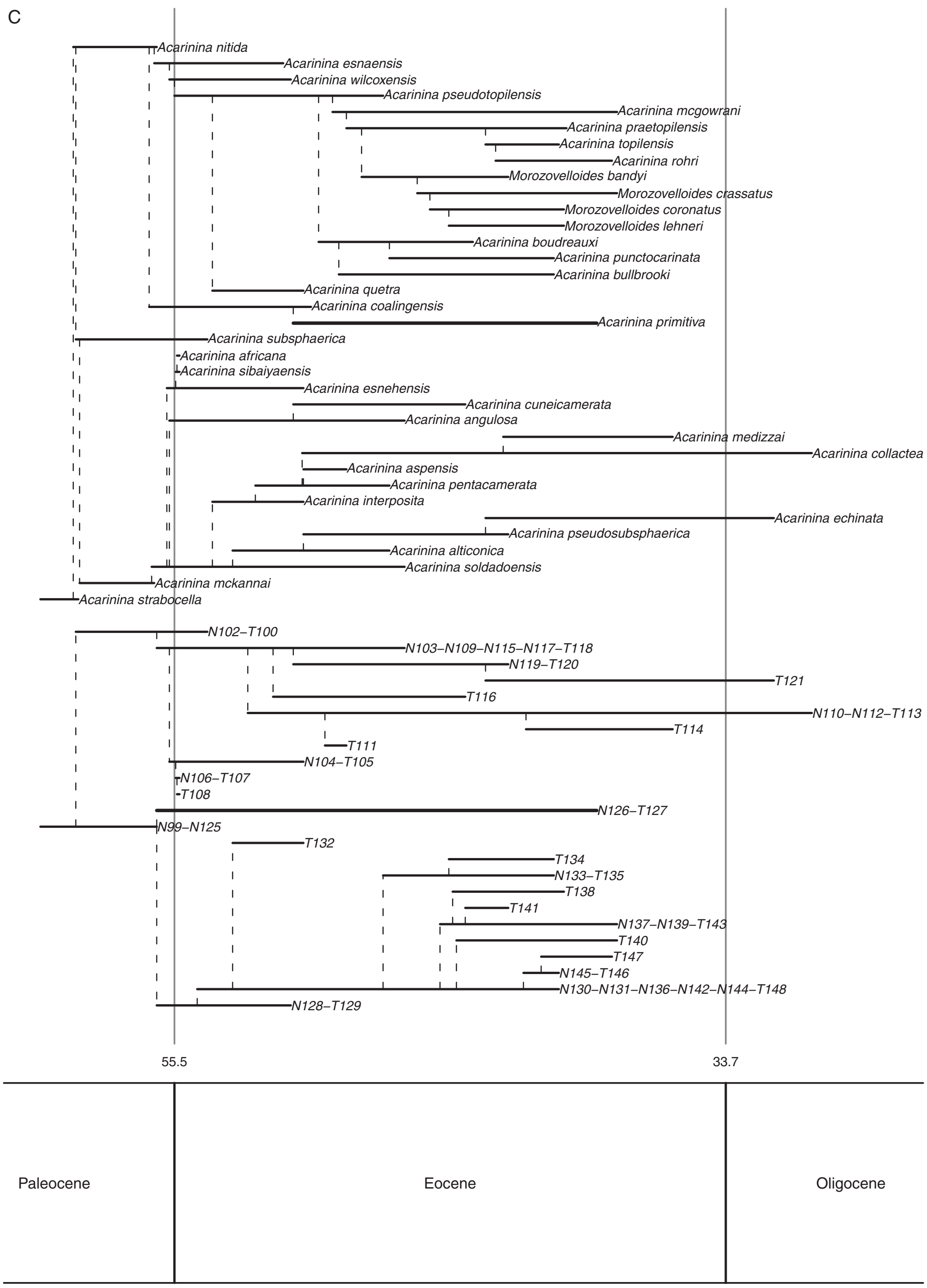

Fig. 5. (C) Descendants of *Acarinina strabocella* shown as both morphospecies (top) and evolutionary lineages (bottom). *A. strabocella* is descended from *Morozovella praeangulata* (see B). *Acarinina primitiva* and its corresponding lineage (highlighted with bold lines) have descendants which are detailed in D. *(Cont.)*

(3) Distinction between budding and bifurcating relationships within the lineage phylogeny

Cladogenetic events in the lineage phylogeny can be of two types—budding or bifurcating. At budding cladogenetic events, a new lineage arises whilst the ancestral form remains morphologically the same and persists to coexist with the new lineage. Bifurcating events occur when a lineage splits into two morphologically distinct entities, both different from the ancestral lineage that gave rise to them, which then ceases to exist (compare Fig. 1A & B). Vertical lines on this phylogeny correspond to Simpson's (1951) concept of evolutionary species (Fig. 3A, with detail in Fig. 5) which is more inclusive

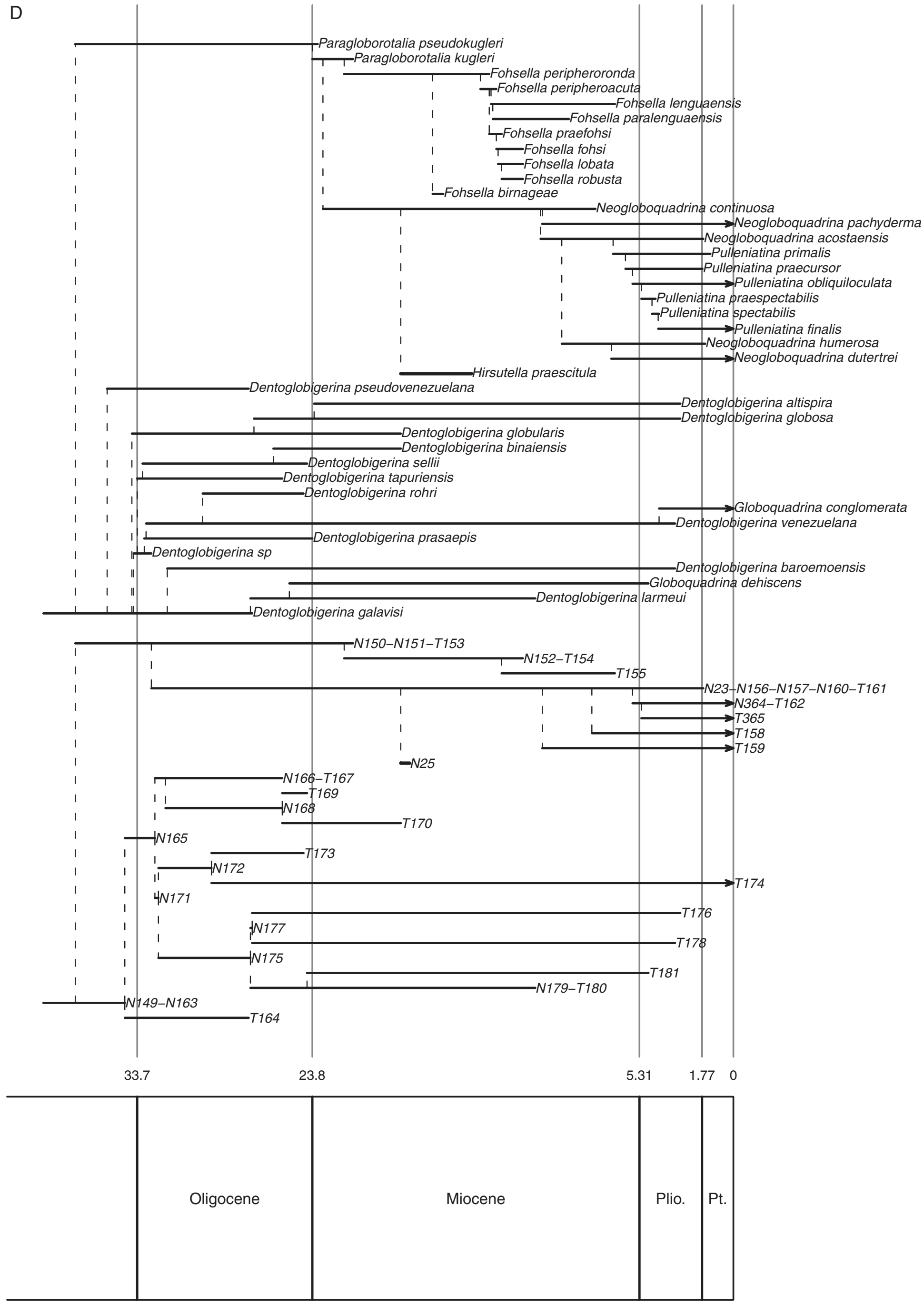

Fig. 5. (D) Descendants of *Dentoglobigerina galavisi* shown as both morphospecies (top) and evolutionary lineages (bottom). *D. galavisi* is descended from *Acarinina primitiva* (see C). *Hirsutella praescitula* and its corresponding lineage (highlighted with bold lines) have descendants which are detailed in E. *(Cont.)*

than the Hennigian concept because ancestors are permitted to persist through a speciation event.

(4) Assignment of taxa to morphogroups and ecogroups

The morphospecies and lineages presented in the phylogenies were assigned to morphogroups based upon distinctive architectural features of the test and are separated into two major divisions—those with spines and those without (Table 2). The online supporting information (Appendices 2 & 3) superimposes morpho- and ecogroups onto the lineage and morphospecies' phylogenies, and the complete assignment and relational database is available in online Appendix 1.

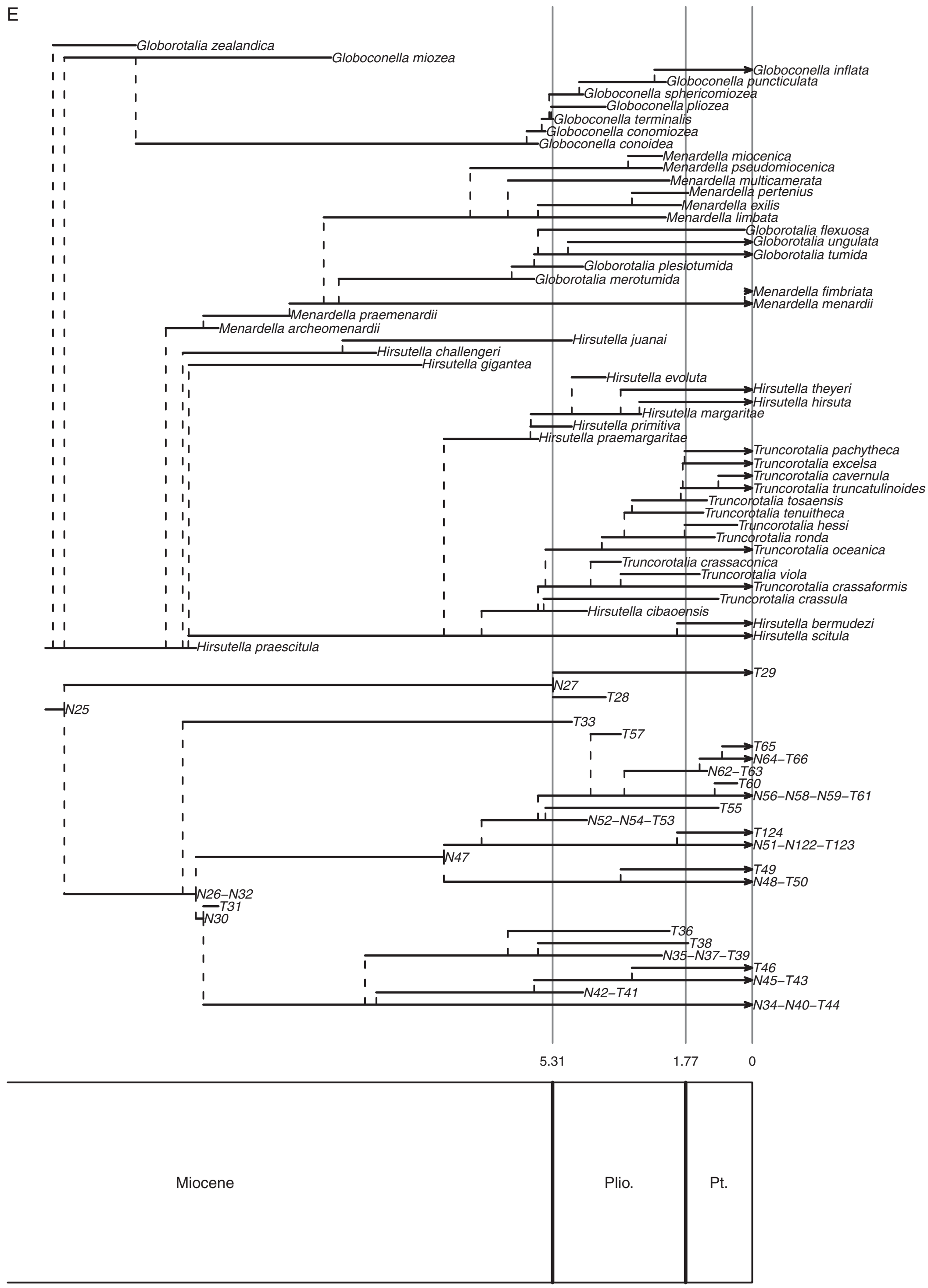

Fig. 5. (E) Descendants of *Hirsutella praescitula* shown as both morphospecies (top) and evolutionary lineages (bottom). *H. praescitula* is descended from *Neogloboquadrina continuosa* (see D). *(Cont.)*

Morphospecies were also assigned to ecogroups, based on geochemical information from foraminiferal calcite and geographical information about environmental preference. Carbon (δ^{13}C) and oxygen (δ^{18}O) isotopic signatures of foraminiferal tests partly reflect the ambient water chemistry at the time of calcification and also biotic and kenetic fractionations of dissolved inorganic carbon from which the foraminifera construct their tests (see Hemleben *et al.*, 1989 and Rohling & Cooke, 1999, for a review). The carbon isotope ratio varies with water mass and depth in

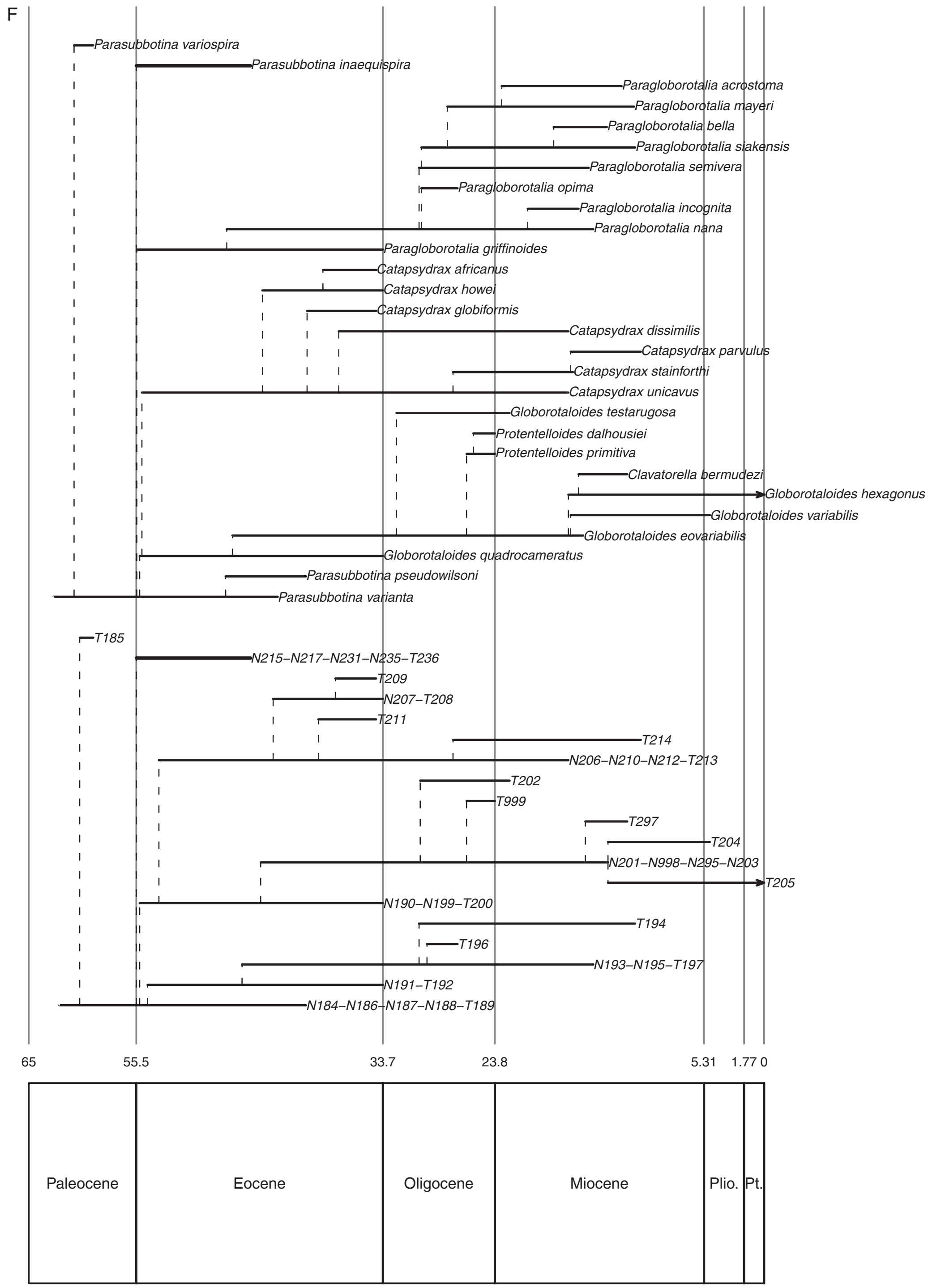

Fig. 5. (F) Descendants of *Parasubbotina varianta* shown as both morphospecies (top) and evolutionary lineages (bottom). *P. varianta* is descended from *Parasubbotina pseudobulloides* (see A). *Parasubbotina inaequispira* and its corresponding lineage (highlighted with bold lines) have descendants which are detailed in G. *(Cont.)*

the water column, with heavier ratios being found in surface waters where algal photosynthesis preferentially removes the light isotope, which is reintroduced at depth through respiration. Two major processes that overprint $\delta^{13}C$ in foraminiferal calcite have been taken into account when assigning the morphospecies and lineages to the distinct ecogroups. The first is photosymbiosis: the presence of algal symbionts around the foraminifera tends to increase the levels of the heavier carbon isotope, which is reflected in the foraminiferal calcite (Spero & Deniro, 1987). The second

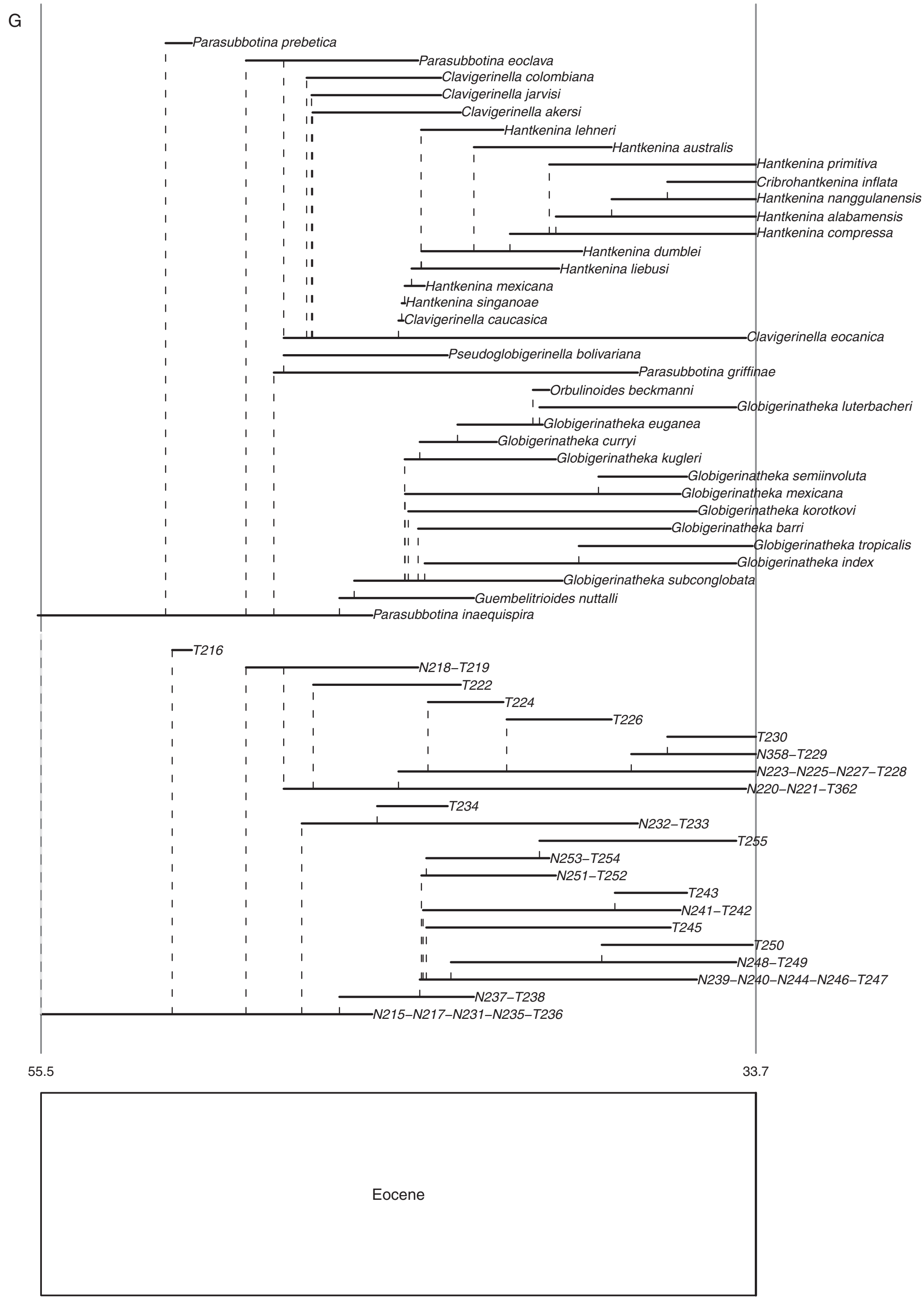

Fig. 5. (G) Descendants of *Parasubbotina inaequispira* shown as both morphospecies (top) and evolutionary lineages (bottom). *P. inaequispira* is descended from *P. varianta* (see F). *(Cont.)*

is the size of the test: small forms <150 μm are subject to a metabolically influenced microenvironment which results in relatively lighter carbon isotope values (Norris, 1996). The oxygen isotopic ratio reflects the isotopic ratio of sea water with a significant temperature-related fractionation. Foraminifera that live in warmer surface waters have lighter (δ^{18}O) than those that calcify in colder deeper water. The combination of these isotopic signatures with geographic

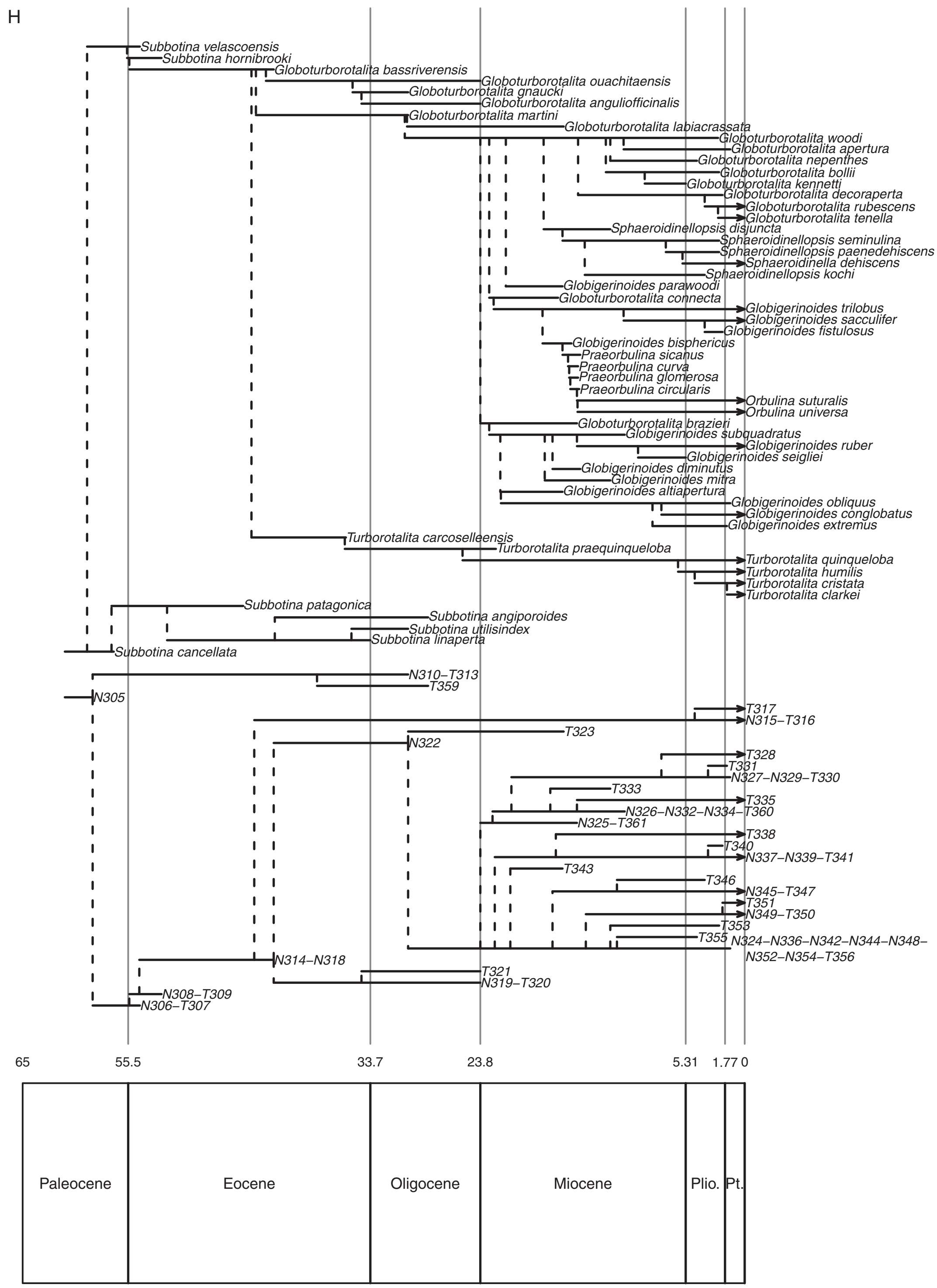

Fig. 5. (H) Descendants of *Subbotina cancellata* shown as both morphospecies (top) and evolutionary lineages (bottom). *S. cancellata* is descended from *Subbotina trivialis* (see A). *(Cont.)*

distributions permits species to be assigned to one of six ecogroups (Table 3).

It is anticipated that morphogroup information will aid future research assessing the iterative nature of morphological characters within lineages and across the clade as a whole, and allow us to assess the extent and distribution of homoplasies within the phylogenies. Ecogroup information will also provide means to investigate how ecological niche space is occupied throughout the whole Cenozoic and during periods perturbed by significant environmental changes, such

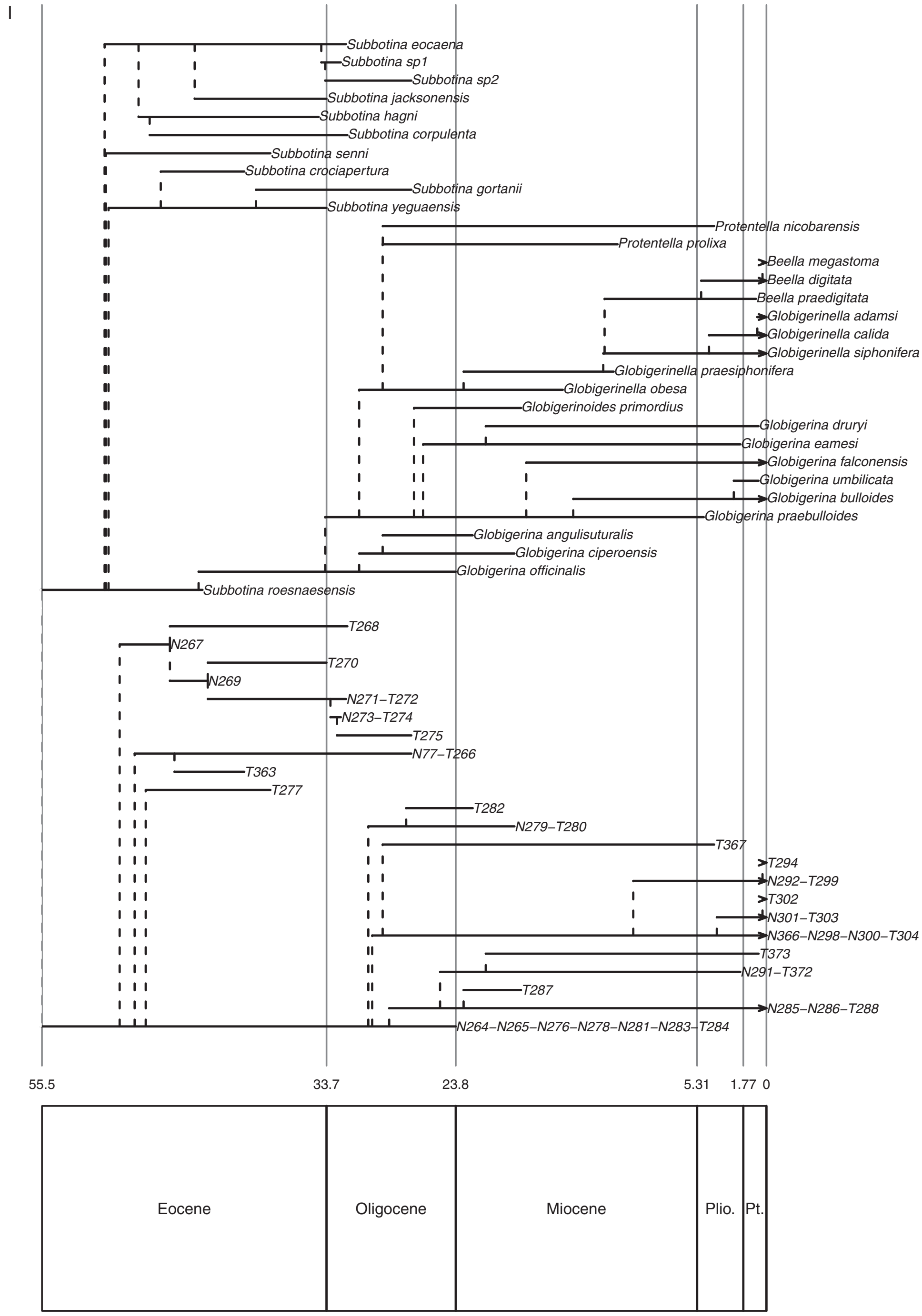

Fig. 5. (I) Descendants of *Subbotina roesnaesensis* shown as both morphospecies (top) and evolutionary lineages (bottom). *S. roesnaesensis* is descended from *Subbotina triangularis* (see A). *(Cont.)*

as the PETM and the transition into icehouse climates at the beginning of the Oligocene.

(5) **Assessment of the completeness of the fossil record**

The completeness and accuracy of our phylogeny depend on the fossil record being sufficiently complete that the stratigraphic ranges assigned to morphospecies can be trusted. We used the data in the NEPTUNE database (Lazarus, 1994; Spencer-Cervato, 1999) from 165 holes drilled by the DSDP and ODP, to generate a minimum estimate of the completeness of the record for Cenozoic macroperforate planktonic foraminifera. Species could have sparse records within their stratigraphic ranges for three reasons: they might have a very incomplete fossil record;

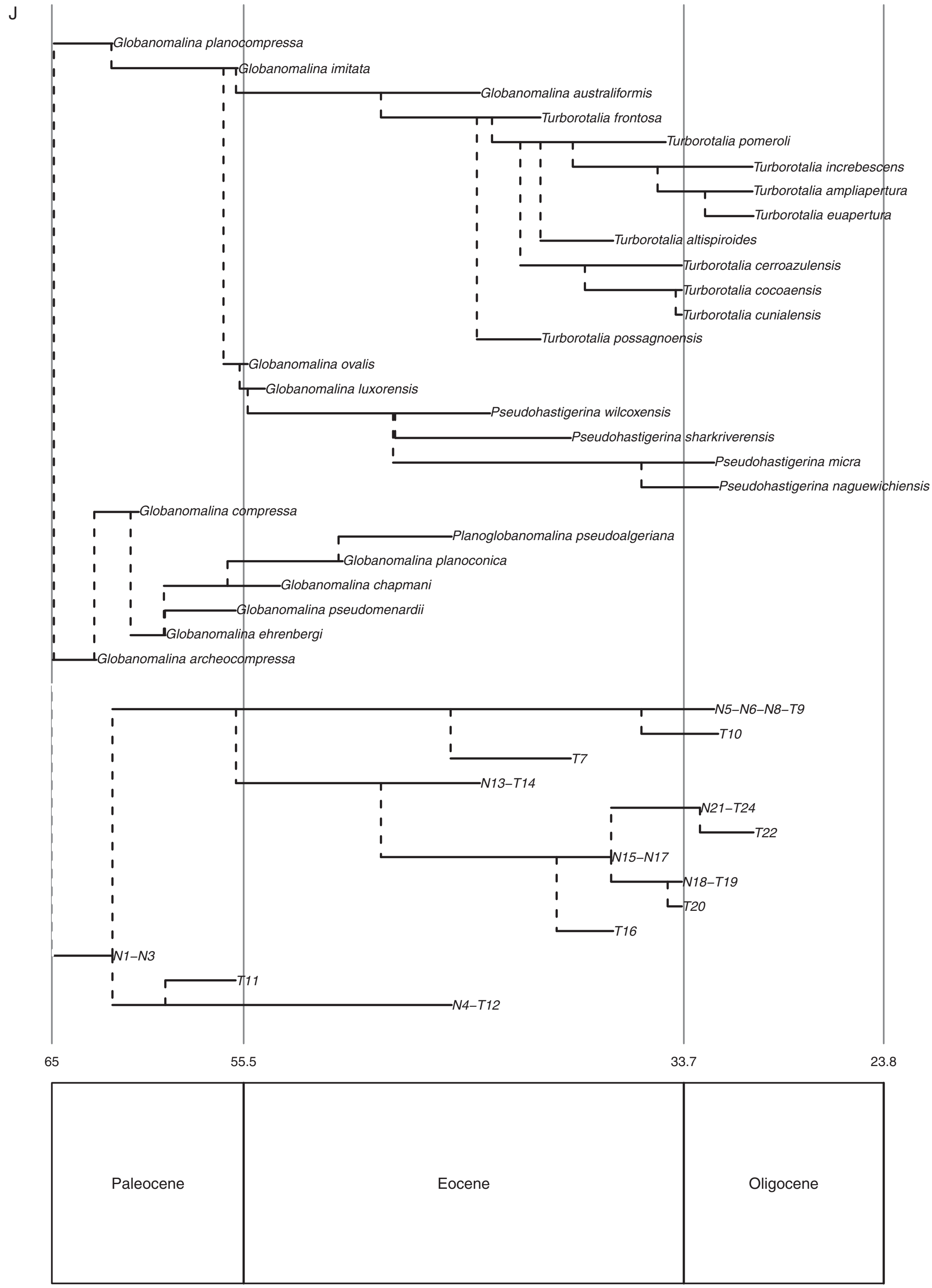

Fig. 5. (J) Descendants of *Globanomalina archeocompressa* shown as both morphospecies (top) and evolutionary lineages (bottom). *G. archeocompressa* is descended from *Hedbergella holmdelensis* (see A). Further details of the morphospecies included in the evolutionary lineages is available in the online supporting information (Appendix 1, Table S3, columns headed ID and LID) along with the data required for constructing both of the phylogenies presented and the according Hennigian lineage phylogeny (Appendix 5). The timescale is from Berggren *et al.* (1995), Berggren & Pearson (2005) and Wade *et al.* (2011) and the figure was drawn using paleoPhylo (Ezard & Purvis, 2009).

Table 2. Morphogroup descriptions, which split the macroperforate planktonic foraminifera into two main groups (spinose and non-spinose), with substantial morphological variation providing subdivisions (example genera shown)

Spinose	flat	*Turborotalita*
	globular	*Subbotina, Globigerina, Globoturborotalita*
	globular with supplementary apertures	*Globigerinoides, Globigerinatheka, Guembilitriodes*
	spherical	*Praeorbulina, Orbulina, Orbulinoides, Globigerinatheka*
	clavate	*Beella*
	planispiral	*Globigerinella*
Non-spinose	globular	*Globoquadrina*
	globular, keeled	*Pulleniatina spectabilis*
	planispiral	*Pseudohastigerina*
	tubulospinate	*Hantkenina*
	keeled spines	*Astrorotalia*
	turborotaliform, keeled	*Turborotalia*, some *Truncorotalia, Fohsella*
	turborotaliform, non-keeled	*Hedbergella*
	globorotaliform, keeled	*Menardella*
	globorotaliform, anguloconical	some *Truncorotalia*
	globorotaliform, non-keeled	*Hirsutella*
	muricate, acarininiform	*Acarinina*
	muricocarinate, keeled	some *Morozovella, Morozovelloides*
	muricocarinate, anguloconical	some *Morozovella, Morozovelloides*

Table 3. Ecogroup definitions, with associated chemical composition and/or geographical limit signatures

Ecogroup	Signature
Open ocean mixed-layer tropical/ subtropical, with symbionts	Very heavy δ^{13}C and relatively light δ^{18}O
Open ocean mixed-layer tropical/ subtropical, without symbionts	δ^{13}C lighter than species with symbionts; also with relatively light δ^{18}O
Open ocean thermocline	Light δ^{13}C and relatively heavy δ^{18}O
Open ocean sub-thermocline	Very light δ^{13}C and very heavy δ^{18}O
High-latitude	Species that are only found in high-latitude sites
Upwelling/high productivity	Species that are only found in sites of high productivity or upwelling

they might have a complete record but the data are from cores not in NEPTUNE; or they might be underrepresented in NEPTUNE because of taxonomic changes. Sparse records are therefore hard to interpret, but finding that most species have very complete records would imply that the fossil record is sufficiently complete to support our approach.

We matched 85,742 occurrence records from NEPTUNE (downloaded on 16 August 2009) to the 340 morphospecies in the phylogeny, using the taxonomic literature cited above to resolve synonyms where necessary. Over 8,000 further records could not be linked unambiguously to a single morphospecies for a range of reasons: some records were not identified to species (e.g. "*Globigerina* sp.", *Globigerina bulloides* s.l.") or only tentatively so [e.g. "*Globigerina druryi* (q)"], while others were given names that have since been referred to multiple species through changes in taxonomic concepts.

Of the 340 morphospecies in the tree, 51 have no occurrence records in the database. Some are newly described species and are too recent to be included in the database but many are Paleocene forms which have been subject to recent review by the Paleocene and Eocene Working Groups (Olsson *et al.*, 1999; Pearson *et al.*, 2006). These species are in groups that have seen recent taxonomic changes or may be rare excursion taxa (short-lived taxa characteristic of times of environmental perturbation, such as *Acarinina africana* during the PETM) which are uncommon in the fossil record but nevertheless have been found to be valid species.

For each of the remaining 289 morphospecies, we calculated the proportion of its duration (according to the phylogeny) that is represented in the database, as the proportion of time bins containing at least one recorded occurrence. At a bin length of 1 million years, 173 species (60%) have complete fossil records, i.e. every bin contains a record. Across the 289 species, the mean completeness is 83.4% and the median completeness 100%. Even at a bin length of 0.5 million years, 126 species (44%) have complete records, median completeness is 91.7% and mean completeness 77.2%. These figures, especially when the limitations of NEPTUNE are considered, suggest that the species-level fossil record of Cenozoic macroperforate planktonic foraminifera is at least as good as the genus-level records of the best-preserved macroinvertebrate groups (quantified by Foote & Sepkoski, 1999).

(6) Comparison with molecular phylogenies

The only gene to have been sequenced across a wide range of morphospecies so far is SSU rDNA. However, extreme rate heterogeneity among lineages, coupled with variable length 'expansion sequences' found only within this group, complicate alignment, with the result that most studies have analysed only approximately 600 base pairs from the 3′ end of the gene (Aurahs *et al.*, 2009). The first large-scale attempts to understand phylogeny within the group came with Darling *et al.*'s (1997) neighbour-joining tree which includes eight planktonic species. It concords with our phylogeny on the relationships between *Globigerinoides ruber, G. conglobatus, G. trilobus, Orbulina universa* and *Globigerinella siphonifera*; their tree differs from ours in having *Globigerina* associated with *Menardella menardii*, perhaps because of long-branch attraction, and in having *Neogloboquadrina dutertrei* originating from within a large group of benthic species, a highly discrepant placement. Only one of the seven clades in Darling *et al.*'s (1997) tree—*G. ruber* + *G. conglobatus*—is compatible with de Vargas *et al.*'s (1997) phylogeny, which includes the same eight species plus four others. de Vargas *et al.*'s (1997) maximum parsimony analysis recovers Globorotaliidae and Globigerinidae as clades, consistent with our tree, but places the genus *Hastigerina* as sister to Globigerinidae. The authors pointed out that rate heterogeneity was apparently biasing phylogenetic inferences, noting that the apparent close relationship between *Truncorotalia truncatulinoides* and *M. menardii* (which both have rapidly evolving SSU rDNA) is at odds with the clear origins of *Truncorotalia* from within (slow-evolving) *Hirsutella* in the fossil record.

The most recent synthesis of molecular phylogeny of the group (Aurahs *et al.*, 2009) includes 14 of the morphospecies in our phylogeny. Aurahs *et al.* (2009) ameliorate the difficulties of alignment by using eleven different automated alignment algorithms on complete sequences, analysing each resulting alignment by maximum likelihood. Only one superspecific clade—*Globigerinoides ruber* + *G. conglobatus* (with the latter nested within the former)—was strongly supported in all nine trees estimated from the alignments that were considered adequate, but the most typical tree (their Fig. 3) has eight of a possible 13 clades in common with our phylogeny. Their tree agrees with ours on a basal split between globigerinids and Globorotaliidae though, like de Vargas *et al.* (1997), they have weak support for *Hastigerina* being within the macroperforate crown group. Agreement is generally good within the globigerinids—for example, *Orbulina universa* is closest to *Globigerinoides sacculifer*, *Globigerinoides ruber* is closest to *G. conglobatus* (but paraphyletic with respect to it in the molecular phylogeny), and these four species also form a clade. Relationships within Globorotaliidae are less congruent, with long-branch attraction still tending to place *Truncorotalia truncatulinoides* as sister to *Menardella menardii* to the exclusion of *Hirsutella*. Aurahs *et al.*'s (2009) analysis also highlights some probable misidentifications that may have hampered earlier analyses.

Some of the long branches may be broken up in future by improved sampling of taxa. Sequencing additional genes (which has begun: Longet & Pawlowski, 2007) will also reduce the problems of rate heterogeneity if they show different patterns of rates, and should increase resolving power. The development of extraction procedures that do not destroy the tests (Morard *et al.*, 2009) will increasingly permit checking of morphospecies identifications—valuable given that the sequenced specimens may not yet have laid down their later chambers, whose characters are often important in species taxonomy. The preservation of the tests would also allow for sometimes subtle morphological differences to be mapped onto the genetic units allowing for further incorporation into palaeontological trees. However, our phylogeny suggests that, even with these advances, robustly resolving basal relationships within the macroperforate clade from sequence data will still be difficult because the early divergences were close together in time (Rokas *et al.*, 2005).

Many molecular studies have found deep divergences within extant morphospecies. Darling & Wade (2008) report 53 genotypes within 17 macroperforate species. Ujiie & Lipps (2009), using the more stringent criteria of 90% posterior probability and 2% sequence divergence from other groups, find 28 distinct genotypes within the 14 macroperforate species that were multiply represented within their dataset. Göker *et al.* (2010) clustered a distance matrix derived from sequence data to maximise the goodness-of-fit to morphology-based taxonomy; they found a lower ratio of putative genetic taxa (i.e. clusters) to morphospecies, perhaps reflecting the way they tuned their approach to morphospecies. Genetic species can be delimited statistically based on sequences of a single gene from a geographically inclusive sample of individuals, by identifying where the tempo of branching switches from population-level coalescence to among-species phylogeny (Pons *et al.*, 2006), but this approach has so far not been applied to planktonic foraminifera.

V. SUMMARY EVOLUTIONARY HISTORY OF THE CENOZOIC MACROPERFORATE PLANKTONIC FORAMINIFERA

The macroperforate planktonic foraminifera survived the end-Cretaceous mass extinction 65 Ma, but only just: their diversity prior to this event was about 50 morphospecies (Caron, 1985) but only two species survived into the Cenozoic (Olsson *et al.*, 1999). In the first million years of the Early Paleocene, the roots of the major clades of Cenozoic macroperforate planktonic foraminifera were established, with the appearance of non-spinose types such as turborotaliiform non-keeled forms as well as non-spinose and spinose globular forms (Coxall, D'Hondt & Zachos, 2006). The acquisition of spines was an innovation that occurred in the earliest Cenozoic (Hemleben *et al.*, 1991), and is hypothesized to indicate a transition to a carnivorous feeding niche and the initiation of hosting photosynthetic algal symbionts (Olsson *et al.*, 1999). In modern forms, spines are mostly associated with photosymbiosis, and are found in just under half of macroperforate morphospecies (Hemleben *et al.*, 1989).

Diversity increased steadily during the Paleocene with over 20 morphospecies recorded at the Paleocene-Eocene boundary (55 Ma). The Eocene was a time of innovation and radiation, when planktonic foraminiferal morphology became increasingly disparate with the reappearance of ornate groups, including clavate, tubulospinose and keel-spined forms. Many of the morphological iterations, such as the acquisition of a keel and clavate chambers, are hypothesized to be associated with the invasion of new depth habitats and ecological niches (Norris, 1991; Coxall *et al.*, 2007). The peak of recorded macroperforate planktonic foraminiferal diversity was during the middle Eocene, with over 60 different recorded morphospecies coexisting.

The initiation of glaciation during the Oligocene appears to have had a profound effect upon the global diversity of the clade. Morphospecies diversity had declined steadily throughout the later Eocene, but a notable extinction event is seen at 33.7 Ma (Eocene-Oligocene boundary): standing morphospecies diversity dropped suddenly from over 40 to under 30, and many morphogroups, such as the spinose tubulospinose and keel-spined forms, were lost altogether (Wade & Pearson, 2008).

Morphospecies diversity remained relatively constant throughout the entire Oligocene with an eventual rise in diversity beginning in the Neogene (23.7 Ma to present). Diversity slowly and steadily increased through the Miocene, with the proliferation of smooth-walled, non-spinose globorotaliform species and spinose globular forms. A sharp increase in morphospecies number within the final two million years of the Miocene epoch led to levels comparable to those of the Middle Eocene. Diversity remained high until a notable decline that began at the end of the Pliocene and continued into the Pleistocene.

Iterated evolution of morphology (Norris, 1991; Coxall *et al.*, 2007) and ecology (Hart, 1980) have been hypothesised previously. However, mapping the morphogroup and ecogroup transitions onto the phylogenies (see online supporting information, Appendices 2 & 3) shows the iterative pattern to be more complicated than initially envisaged. Repeated evolution of morphology and ecology seems to be spread across the clade as a whole, rather than one root stock giving rise to multiple lineages with iterated patterns occurring frequently, as initially envisaged by Cifelli (1969). Further work will be needed to investigate the macroevolutionary mechanisms that drive such patterns across much of this group.

VI. PHYLOGENIES AND DATABASES AS WINDOWS ON MACROEVOLUTION

Palaeobiologists often infer macroevolutionary dynamics from temporal data on the occurrence of taxa. Such studies have been greatly facilitated by the development of large databases that record either first and last (Raup & Sepkoski, 1982; Benton, 1993) or a sample of all (Lazarus, 1994; Alroy *et al.*, 2001) known occurrences. Although the NEPTUNE database (Lazarus, 1994) contains over 90,000 records of Cenozoic planktonic foraminifera, the phylogeny we present has four important advantages over the database for conducting macroevolutionary analysis. Three of these are conferred by the taxonomic oversight given by the working groups, while the fourth concerns the nature of phylogenies.

(1) Consistency of taxonomic concepts

Taxonomic concepts may have changed subtly or radically with time. For genera, the historical tendency has been to split on uncovering evidence of polyphyly. Consequently, the old concept of a genus can have much longer range than does its current concept (e.g. the stratigraphic range of *Globigerina* has been reduced because Eocene taxa once referred to it are now viewed as subbotinids). For morphospecies, an analogous splitting process has also often taken place (e.g. the name *Acarinina pseudotopilensis* is now applied much more stringently than it was for much of its history; Pearson *et al.*, 2006). Ongoing taxonomic work, especially S.E.M. investigation of type specimens, has resulted in some major revisions of taxonomic usage; as an example, *Globorotaloides suteri* was a widely recognised taxon but has recently been placed in synonymy with another common taxon, *Catapsydrax unicavus*; individuals previously assigned to *G. suteri* are now mostly referred to *G. eovariabilis* (Pearson *et al.*, 2006). Some taxa (e.g. *Acarinina mcgowrani*) have been described since most or all of the samples documented in the database were analysed, and so are underrepresented or absent. Additionally, some taxa have been conceptualized broadly by some workers ('lumpers') and narrowly by others ('splitters'); in these instances the total stratigraphic range given in a database tends to favour lumping. In extreme cases, taxa may have the appearance of 'wastebasket taxa' that are used in a generalized sense and hence with greatly extended ranges (e.g. *Globigerina bulloides*).

(2) Quality control uncertainty

It is always difficult and often impossible to assess the reliability of taxonomic identifications of the many workers who have contributed to any very large database, each with their own set of taxonomic concepts and level of expertise and experience. Any misidentifications from outside the actual stratigraphic range of a morphospecies will artificially extend that range. Conversely, some workers have opted not to attempt species-level identification within taxonomically difficult genera (e.g. *Hantkenina*), tending to reduce the recorded ranges of the morphospecies therein. This taxonomic quality control is also accompanied by an abundance quality control. As it is not essential that NEPTUNE data are an accurate reflection of the actual diversity in each sample the data are inherently biased to the most stratigraphically important taxa used for dating sediment and those that are easiest to identify.

(3) Consideration of reworking and down-hole contamination

Reworking (the appearance of species in sediments dated prior to their inferred origination) of microfossils can be common. When such occurrences are included in the database they extend the stratigraphic ranges upward, often by a large amount. Many probable examples of this can be seen in NEPTUNE, although in the absence of information on the sedimentological context and taphonomy of each occurrence it is often impossible to determine whether it is reworked or possibly a rare survivor (e.g. *Hirsutella praescitula* in the middle and upper Miocene). A related but rarer problem is down-hole contamination of microfossils as a result of soft-sediment mixing or caving. This will extend stratigraphic ranges downward (i.e. towards deeper time). Some probable examples of this have been identified (e.g. *Pulleniatina obliquiloculata* has been found in sediment dated to the middle Miocene; Pearson, 1995). The taxonomic working groups have considered these issues when inferring first and last appearance dates. The given dates of first and last occurrences are typically inferred from the best cores for the purpose, i.e. those offering expanded and complete coverage of the relevant interval and showing little sign of displacement.

These three issues mean that the stratigraphic ranges underpinning the phylogeny are mostly narrower than would be obtained from a literal reading of NEPTUNE, except for recently described taxa. The phylogenetic approach we employ also carries a fourth advantage, detailed below.

(4) Evolutionary lineages as units

Pseudoextinction and pseudospeciation (i.e. anagenetic change of a single ancestor-descendant series of populations such that later members are given a different name from earlier ones) is known to be prevalent in planktonic foraminifera. Morphospecies and even genera can originate without any lineage-splitting; for example, *Sphaeroidinella* originates at the point in time when a supplementary aperture appears in *Sphaeroidinellopsis seminulina*, and the two forms intergrade in time (Malmgren, Kucera & Ekman, 1996). Consequently, rates of true speciation and extinction are hard to disentangle from rates of anagenetic change in analyses based on morphospecies. We have attempted to identify the evolutionary lineages underlying the morphospecies. Inasmuch as we have been successful, each lineage originates with a speciation event; depending on the choice of lineage concept, each lineage disappears at an extinction event (evolutionary species) or through either speciation or extinction (Hennigian species), but not through anagenesis.

VII. PROSPECTS

Lineage phylogenies such as we have presented here therefore provide the closest approximation to the theoretical and simulated phylogenies that have underpinned many of the palaeobiological developments in macroevolution (e.g. Raup *et al.*, 1973; Raup, 1985; Foote, 2001; Roy & Goldberg, 2007), and so provide the most promising system available for testing a range of macroevolutionary hypotheses (Purvis, 2008; Benton, 2009). The frequency of pseudospeciation and pseudoextinction is not known in general, but is a source of noise and bias in macroevolutionary analyses. We estimate approximately 40% of morphospecies extinctions to be pseudoextinctions within this clade. Many previous analyses of rates of first and last appearances of taxa in planktonic foraminifera (e.g. Allen *et al.*, 2006; Pearson, 1995; Doran *et al.*, 2006) have therefore mixed cladogenesis and extinction on the one hand with anagenesis on the other. Both processes are of interest, and lineage phylogenies permit them to be disentangled.

As well as attempting to eliminate pseudospeciation, our two lineage phylogenies embody different species concepts, which support different kinds of question. For example, it is reasonable to ask of evolutionary species, but not of Hennigian species, whether production of daughter species affects their own survival and future speciation potential (Pearson, 1998*b*). The different concepts also yield different ages for species. The ages of evolutionary species (Simpson, 1951; Wiley, 1978) have more natural evolutionary meanings than either the time since first appearance of a morphospecies (commonly used in palaeobiology) or the time since the most recent common ancestor shared with another extant species (commonly used in phylogenetic comparative studies). The importance of this additional, biologically relevant information present in lineage phylogenies is an interesting open question.

Cryptic diversity presents another challenge for macroevolutionary studies, the resolution of which will require input from both molecular phylogeneticists and morphologists. Algorithmic approaches have been developed for delimiting genetic species based on either single genes (e.g. Pons *et al.*, 2006) or multiple unlinked loci (e.g. Knowles & Carstens, 2007). Application of these approaches to planktonic foraminifera would provide a valuable line of evidence on the frequency of cryptic species, and is facilitated by three ongoing developments: (1) geographic sampling continues to improve (Darling & Wade, 2008); (2) efforts to sequence additional genes to SSU rRNA continue (Longet & Pawlowski, 2007); and (3) DNA extraction no longer requires complete dissolution of the test (Morard *et al.*, 2009). Morphometricians will therefore increasingly be able to analyse the same specimens from which gene sequences are taken, which will greatly enhance the prospects for a fully integrative taxonomy (Vogler & Monaghan, 2007) as well as permitting powerful characterisation of the selective regime under which morphology evolves (Fontaneto *et al.*, 2007). Moving to the fossil record, detailed morphometric and geochemical analyses focusing on periods bracketing apparent speciation events may detect previously unrecognised cryptic diversity (Hull & Norris, 2009) and clarify how anagenesis and cladogenesis are linked.

Although molecular sequence data will be key for species delimitation, the prospects for using them to resolve deep splits in the phylogeny seem less promising. The fossil evidence suggests that many pairs of extant species share their most recent common ancestor in the first ten million years of the clade's radiation (see online supporting information, Appendix 4) and resolution of such short branches so long ago typically requires very large numbers of unlinked genes (Rokas *et al.*, 2005). However, the detailed knowledge of past species and environments means that the group may provide rare opportunities for testing hypotheses for variation in the rate of molecular evolution among lineages.

The construction of lineage phylogenies requires a combination of a comprehensive fossil record, detailed morphospecies-level taxonomic work, and consistency in the use of taxonomic concepts. At present, Cenozoic macroperforate planktonic foraminifera are perhaps the only group for which all the conditions are met; however, the approach will increasingly be possible for other well-known groups, either globally or in particularly well-studied regions, as knowledge of fossil taxa and their relationships continues to accumulate.

VIII. CONCLUSIONS

(1) The phylogenies presented herein are the first synthesis of this group for the whole Cenozoic since Fordham (1986). The evolutionary relationships detailed within the Paleocene and Eocene are likely to be the most robust, due to the recent publication of Atlases by the Paleogene working group (Olsson *et al.*, 1999; Pearson *et al.*, 2006).

(2) Attention is required in the late Paleogene and Neogene, with particular focus needed upon the origin of the globorotaliid clade. The Paleogene Working Group is currently preparing the *Atlas of Oligocene Planktonic Foraminifera*, which will complete the major revision of the Paleogene planktonic foraminifera begun in 1987.

(3) As a consequence of the continuing endeavours of the many scientific workers focusing their efforts upon more detailed morphometric and genetic analysis of this group, it is anticipated that some of the relationships detailed herein may change or be falsified by new work. Nevertheless, this assessment of completeness of the record illustrates the excellent quality of the fossil record for this group and reinforces their suitability for a stratophenetic phylogenetic construction.

(4) The synthesis of many phylogenies into one large phylogeny provides the opportunity to appreciate graphically the evolutionary history of this exceptional fossil group. The phylogenies provide frameworks and testable hypotheses for macroevolutionary investigation of how morphologically complex organisms recover and radiate after abrupt climatic upheaval.

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XI. SUPPORTING INFORMATION

Additional supporting information may be found in the online version of this article.

Appendix 1. (A) Summary and definitions of eco- and morphogroup codes and column headings used in Table S3. (B) Table S3. Summary of information used to construct the morphospecies phylogeny, and its subsequent conversion into a lineage phylogeny as documented in the main manuscript. (C) References used in Table S3.

Appendix 2. Figures illustrating the assignment of the different morphospecies and lineages within the phylogenies (budding/bifurcating morphospecies phylogeny, fully bifurcating lineage phylogeny and budding/bifurcating lineage phylogeny) to their respective ecogroups.

Appendix 3. Figures illustrating the assignment of the different morphospecies and lineages within the phylogenies (budding/bifurcating morphospecies phylogeny, fully bifurcating lineage phylogeny and budding/bifurcating lineage phylogeny) to their respective morphogroups.

Appendix 4. Table S4. Divergence times of extant species of Cenozoic macroperforate planktonic foraminifera taken from the evolutionary lineage phylogeny.

Appendix 5. Data required to produce all of the phylogenies included in the manuscript using paleoPhylo (Ezard & Purvis, 2009) a free software package to draw paleobiological phylogenies in R.

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Interplay Between Changing Climate and Species' Ecology Drives Macroevolutionary Dynamics

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Ecological change provokes speciation and extinction, but our knowledge of the interplay among the biotic and abiotic drivers of macroevolution remains limited. Using the unparalleled fossil record of Cenozoic macroperforate planktonic foraminifera, we demonstrate that macroevolutionary dynamics depend on the interaction between species' ecology and the changing climate. This interplay drives diversification but differs between speciation probability and extinction risk: Speciation was more strongly shaped by diversity dependence than by climate change, whereas the reverse was true for extinction. Crucially, no single ecology was optimal in all environments, and species with distinct ecologies had significantly different probabilities of speciation and extinction. The ensuing macroevolutionary dynamics depend fundamentally on the ecological structure of species' assemblages.

The wide-ranging mechanisms that generate and maintain biodiversity have been grouped in many different ways, but a fundamental distinction exists between biotic and abiotic drivers (*1*–*5*). If interactions among species are the dominant drivers of evolution, as in the "Red Queen" model (*1*, *4*), then diversification rates among groups of interacting species are expected to show diversity-dependent dynamics with ongoing turnover at equilibrium. A consequence of this mechanism is that diversification rates are expected to decrease as a function of diversity. Conversely, if evolution is driven chiefly by changes in the physical environment—as in the "Court Jester" model (*3*), named to contrast with the Red Queen—macroevolutionary dynamics should be dominated by cladewide effects of abrupt abiotic perturbations. Although the interplay between these alternative drivers has long been recognized as fundamental for regulating diversity (*6*, *7*), progress toward understanding their interaction has been slow (*2*). The incompleteness of the fossil record often necessitates temporally and taxonomically coarse paleontological analyses (*7*–*10*), whereas molecular phylogenies are restricted to extant species and therefore offer little insight into extinction (*11*, *12*). To distinguish how interwoven biotic and abiotic processes regulate diversity, high-resolution data on multiple forcing mechanisms should be allied to paleontological, species-level phylogenies constructed on sufficiently complete fossil records over substantial periods of evolutionary history. This resolution is rare (*2*, *6*), but Cenozoic macroperforate planktonic foraminifera provide a suitable record for testing these hypotheses (*13*).

Planktonic foraminifera are sexually reproducing protists distributed throughout the world's oceans. The calcium carbonate "shells" (known as "tests") of dead individuals rain down on the ocean floor and can, under favorable conditions, generate continuous microfossil sequences that span millions of years. The group's usefulness for stratigraphic correlation (*14*) and paleoclimatic reconstruction (*15*) has led to extensive documentation of its morphology (*14*) and depth habitats (*13*). The phylogenetic relationships within the macroperforate clade of the Cenozoic have recently been revised comprehensively (*13*), via the application of Simpson's evolutionary species concept (*16*). Under this concept, each species is intended to represent a single line of descent (*16*) that begins with a speciation (clado-

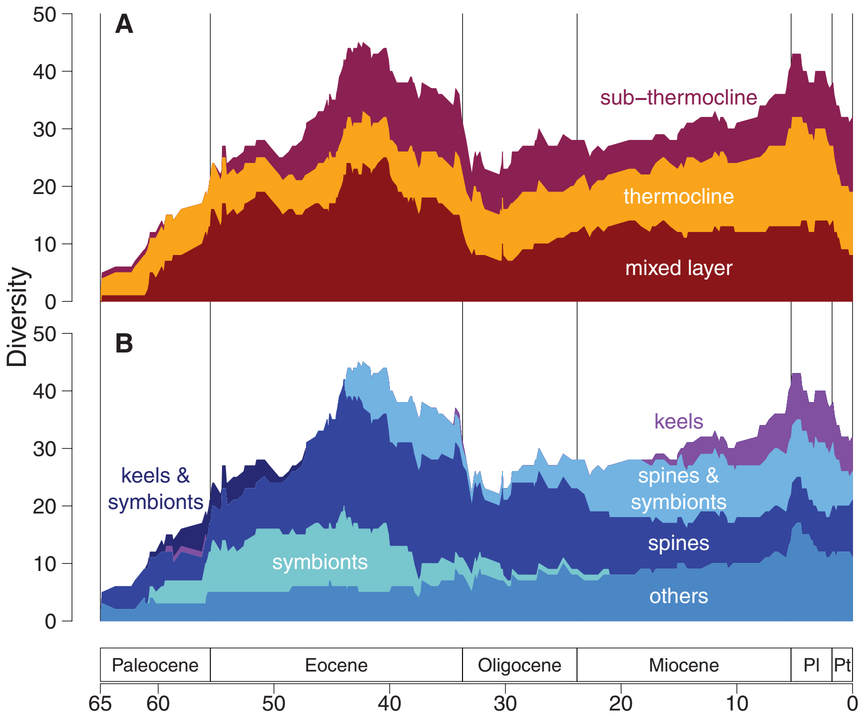

Fig. 1. The relative frequencies of depth habitats (**A**) and morphologies (**B**) of macroperforate planktonic foraminifer species across the Cenozoic (*13*) has fluctuated substantially. Time (million years before the present) is based on the marine geological time scale (*14*). Pl, Pliocene; Pt, Pleistocene.

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genetic) event and ends in extinction. The completeness of this group's fossil record is such that species have at least an 81% chance of being detected per million-year interval (fig. S2). Therefore, this species-level fossil record is at least as good as the best-preserved genus-level records of macro-invertebrates (*17*).

The macroperforate clade has diversified from two species that survived the end-Cretaceous mass extinction into 32 morphologically distinct species today, though the rise in diversity has been far from smooth (Fig. 1). The sharpest fall in diversity occurred during the Eocene-Oligocene transition, when rapid global cooling led to the development of the Antarctic ice cap (*15*). This suggests that climate change has been important in macroevolution, so we used the mean and variability of oxygen isotopic composition of deep-sea carbonates to approximate the complex, multifaceted climate system (*15*, *18*). Clade growth [$\ln\left(\frac{N_t+1}{N_t}\right)$, detrended, where N_t is the number of species in each 1-million-year bin *t*] was poorly predicted by climate (Fig. 2A and table S1) (*18*). Models based on diversity-dependence used diversity only at the start of each bin and assume a constant limit to niche availability (a taxonomic analog to a demographic "carrying capacity"), but predictions were similarly poor (Fig. 2B and table S1). Thus, the clade's macroevolutionary dynamics are not well predicted by either a strictly abiotic (Fig. 2A) or a strictly biotic model (Fig. 2B).

Any clade will be composed of species with distinct ecologies. If these ecologies have conferred a macroevolutionary advantage on certain species over others, models that incorporate ecology will provide a better description of observed changes in macroevolutionary dynamics than if all species are assumed equal. To test this hypothesis, we grouped species by their depth habitat and morphology, which, taken together, we used as a proxy for species' ecology (*18*). Although it is impossible to obtain an experimental link between traits and fitness in fossils, certain traits are thought to indicate functional differences that reflect different ways of life. For example, the acquisition of spines occurred in the earliest Cenozoic and is hypothesized to indicate the transition to a carnivorous diet (*19*) and to have initiated the hosting of photosynthetic algal symbionts (*20*), whereas the evolution of a keel is thought in some instances to be associated with the invasion of new depth habitats (*21*). The assemblage in the warm Eocene oceans was dominated by species inhabiting the mixed layer, whereas most species in the stratified oceans of the Pliocene lived and reproduced near the thermocline, where the temperature gradient is much steeper than elsewhere in the water column. The ecological composition of the clade has fluctuated (Fig. 1), with the relative dominance of each group apparently waxing and waning with the changing climate.

Ecology is more strongly predictive of clade growth than either climate or diversity, but model fit is moderate at best (Fig. 2C and table S1). Models containing interactions among pairs of these variables are significantly better, but model support was strong only when species with distinct ecologies were permitted to respond differently to changes in diversity and climate (evidence weight > 0.99) (Fig. 2F and table S1). The importance of interactions among climate, diversity, and ecology suggests that ecological variation enabled the clade's standing diversity to respond rapidly to climatic fluctuations. This interpretation strengthens arguments that the Red Queen and the Court Jester are not mutually exclusive hypotheses of evolutionary diversification (*2*).

Discrete-time analysis (as is described above) may introduce bias when diversification occurs in continuous time, because there is no ideal bin length to maximize the accuracy of clade-growth estimates (*22*). Here, we use the Euler-Lotka equation (*22*, *23*) to provide an estimate of per-capita growth for an ecologically structured clade with ongoing speciation and extinction. We used parametric survival analysis with censoring (*24*) to obtain parsimonious extinction and spe-

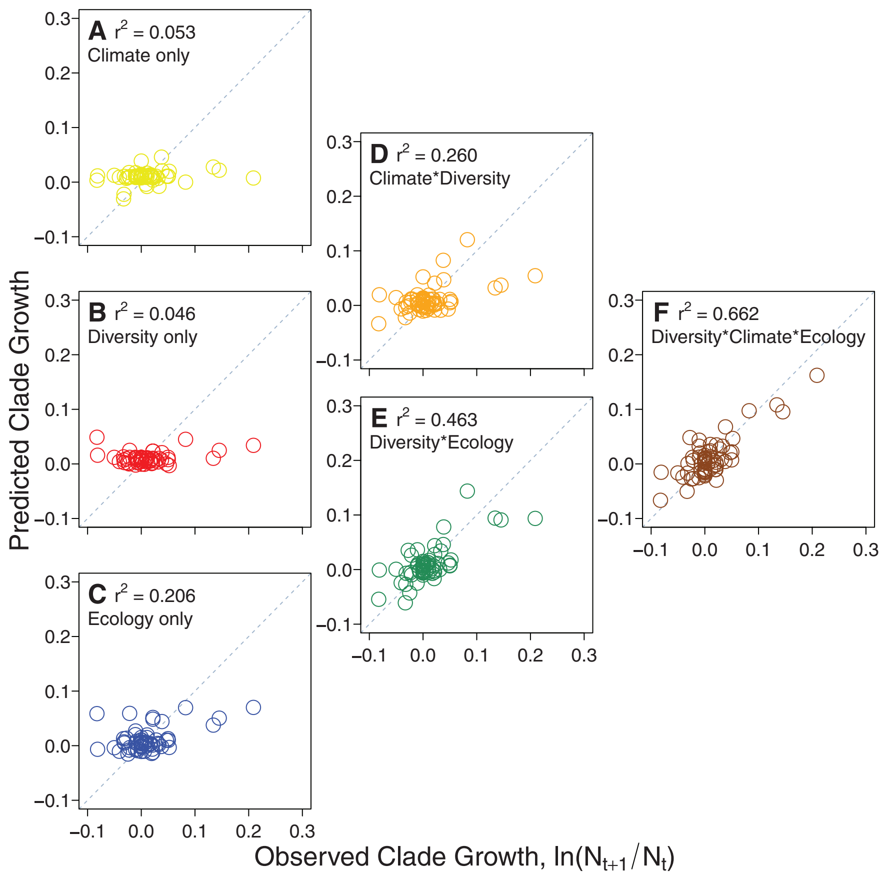

Fig. 2. (**A** to **F**) Discrete time models incorporating interactions among diversity, climate, and species' ecology outperformed all others. The dashed gray line is *y* = *x*; a model that predicts observed clade growth perfectly would have points only on this line. For all summary statistics and models, see table S1. r^2, fraction of total variance explained by the model.

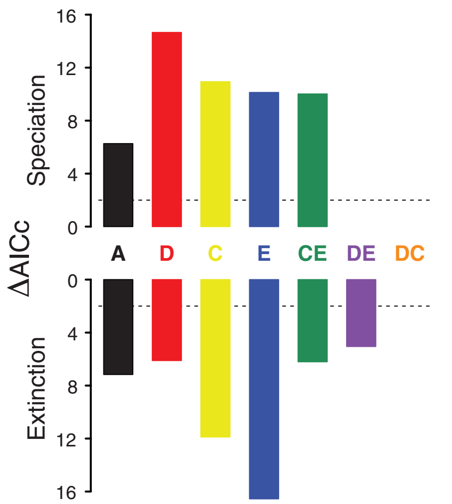

Fig. 3. Speciation probability and extinction risk varied significantly with species' age (A), diversity (D), climate (C), species' ecology (E), and their interactions (letter combinations). The dashed lines denote a difference in corrected Akaike information criterion (ΔAICc) of 2; interactions that did not reach this threshold for "substantial" support and inclusion in the model (*25*) are not shown (*18*).

ciation functions (*18*, *25*). This approach does not resort to discretizing a continuous process and allows direct testing of two cornerstone assumptions of macroevolutionary theory (*26*): The age of a species does not influence its chances of going extinct [i.e., Van Valen's law (*1*)] or of speciating.

Extinction risk increased with age when diversity dependence, climate change, and species' ecology were incorporated. This suggests rejection of Van Valen's law [for similar patterns in morphospecies, see (*27*)], though we note that the lower extinction risk of young species may reflect a veil line in the detection probability of short-lived species over the 65-million-year-long Cenozoic era. We also found that the species most likely to speciate were young (fig. S3). This result is consistent with the frequently observed "early burst" pattern of diversification, in which rapid clade growth occurs over short periods of geological time early in a clade's history and slows thereafter due to diversity dependence (*28*). Speciation probability was affected more by biotic variables than by abiotic ones, whereas the opposite was true for extinction risk (Fig. 3). Species' ecology meant that the impacts of diversity and climatic fluctuations were not felt uniformly across the phylogeny: The extinction and speciation functions differed among species with photosymbionts, keels, and spines, and between greenhouse and icehouse oceans (fig. S3). Identifying a fixed carrying capacity is nontrivial, because the response of any assemblage to climate change depends on the species within it (fig. S4) and differs between speciation probability and extinction risk (Fig. 3). Not all species are one and the same: Ignoring their ecological differences limits our understanding of the clade's macroevolutionary dynamics.

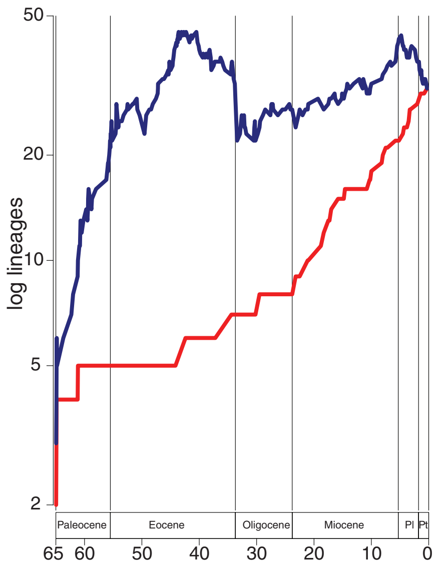

Fig. 4. The impact of extinction on macroevolutionary dynamics of macroperforate planktonic foraminifera is clear when fossil species are used (blue), but not when analysis is based solely on extant lineages (red). Time (million years before the present) is based on the marine geological time scale (*14*).

The continuous-time model gives a deterministic measure of clade growth. We incorporated the impact of changing diversity and climate by parameterizing these variables at speciation and thus assume that conditions early in a species' existence have long-lasting evolutionary consequences. Taking an approach that spans the Cenozoic maximizes the number of bursts of diversification under investigation but restricts our ability to disentangle complex components of climate change and how they affect biodiversity. Despite these limiting assumptions, the continuous-time model captured key features of the macroevolutionary dynamics, such as highest clade growth in greenhouse and highly stratified oceans (fig. S4). The binned analysis is complementary to the continuous-time analysis because it incorporates climate variability during a species' existence (though still assumes a single proxy for climate). The consistency of conclusions from the two approaches supports our interpretation that diversity dependence, climate change, and species' ecology interact to drive macroevolutionary dynamics. Approaches based only on extant diversity can identify some components of diversification (table S4), but they neglect competition among now-extinct species and therefore cannot reveal how biotic interactions among them affected diversity patterns in past environments (Fig. 4).

What biotic and abiotic factors should models of diversification consider? An often-invoked null hypothesis is constancy of birth and death rates; for instance, the constant-rates Markov model (*26*). The ubiquitous importance of species-level diversity dependence in the models presented here violates this fundamental assumption. The less restrictive, equal-rates Markov model permits speciation and extinction probabilities to change through time, provided that they do not vary among contemporaneous species (*26*). This assumption is opposed by our result that young species with similar ecologies are more likely to speciate under particular climatic conditions than older species with other ecologies (Fig. 3 and fig. S4). Finally, speciation probability was more strongly shaped by diversity dependence than by climate change, whereas the reverse was true for extinction risk (Fig. 3). Decomposing macroevolutionary dynamics into its constituent parts is a useful step toward a more complete understanding of how biodiversity is generated and destroyed (*8*).

We conclude that neither the Red Queen nor the Court Jester hypothesis is the dominant macroevolutionary force; instead, it is the interplay of biotic and abiotic variables that regulates diversity and drives speciation and extinction (Figs. 2 and 3). Contrary to recent analyses of global marine diversity patterns (*9*), our results suggest that species' ecology plays a key role in determining overall diversity and gives clearer insights into macroevolutionary dynamics than is possible by treating clades as homogeneous wholes.

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Supporting Online Material

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References and Notes

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